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DEC 81 J F WATLER, D W ROWELL, S S JANOSKI F33615-80-C-3618
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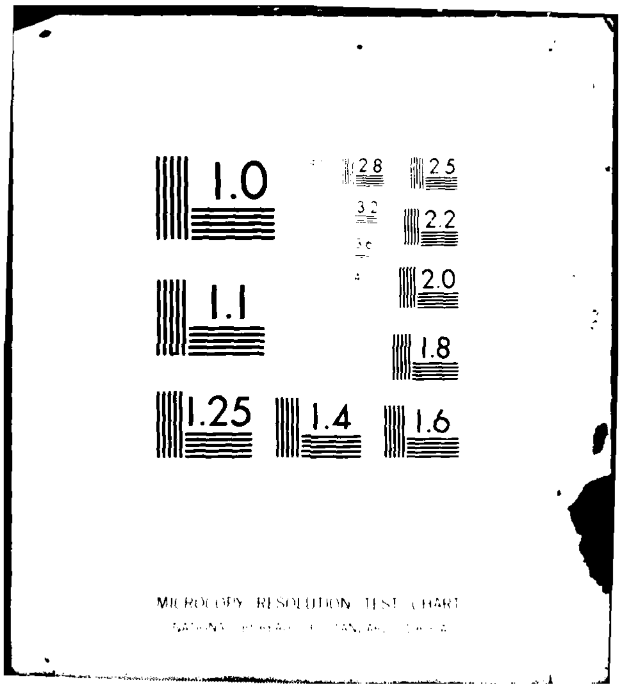
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CREW WORKLOAD PREDICTION STUDY

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December 1981

Final Report for Period July 1980 - December 1981

FLIGHT DYNAMICS LABORATORY
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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER AFWAL-TR-81-3140	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Crew Workload Prediction Study		5. TYPE OF REPORT & PERIOD COVERED Final Report 1 Jul 1980 - 15 Dec 1981
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. F. Watler, Jr. Larry C. Butterbaugh D. W. Rowell S. S. Janoski		8. CONTRACT OR GRANT NUMBER(s) F33615-80-C-3618
9. PERFORMING ORGANIZATION NAME AND ADDRESS NORTHROP, Corp. 1 Northrop Ave. Hawthorne, CA 90250		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 24030430
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Wright Aeronautical Laboratories Flight Control Division (AFWAL/FIGR) Wright-Patterson AFB, OH 45433		12. REPORT DATE December 1981
		13. NUMBER OF PAGES 102
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

KC-135
Avionics Modernization
Workload Assessment
Computer Model
Crew Station Design
Air-refueling
Tanker Aircraft

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents a study which applied an analytic method known as the Controls and Display Evaluation Model, or CODEM, to the flight deck avionics improvements identified in the Flight Control Division's (AFWAL/FIGR) Tanker Avionics and Aircrew Complement Evaluation (TAACE) program. TAACE, in support of the USAF KC-135 Avionics Modernization Program, sought to establish design criteria for the controls and displays of improved avionics, in the event the crew of the KC-135 is reduced by eliminating the navigator. The objective of this study was to apply CODEM to a previously evaluated design, so that

20. Abstract continued......

the resulting data could be used to evaluate the validity of CODEM by comparing the two sets of data. CODEM, which is still in the developmental stage, embodies a 'limit design' approach to the problem of controls and displays engineering and integration. Absolute design limits and progressive tests are used to test the emerging design in terms of task complexity. CODEM output consists of plots of task complexity vs. time and a printout of associated equipment-related tasks which allows the designer to diagnose the source of any undesireable crew loading. CODEM's application to the TAACE flight deck design concluded that the air-refueling mission could be performed without excessive workloads on the crew.

FOREWORD

This technical report documents the results of a contracted effort, performed by Northrop Corporation. The objective was to apply a control and display evaluation model (CODEM) developed by Northrop, to a modernized KC-135 crew station which incorporated advanced avionics in order to reduce the crew size to pilot, copilot, and boom operator. The results of this contract will be used to assess useability and validity of the CODEM, based on comparisons with data generated by full-mission simulations conducted by AFWAL/FIG at Wright-Patterson AFB, OH.

The contract was funded by the Crew Systems Development Branch, Flight Control Division, Flight Dynamics Laboratory, of the Air Force Wright Aeronautical Laboratories, under Work Unit 24030430 entitled "TAACE Workload Prediction Study." The contract was managed by Mr Larry Butterbaugh of the Crew Systems Development Branch (AFWAL/FIGR).

The report covers work performed during the period from 15 July 1980 to 15 December 1981.

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SECTION I
INTRODUCTION

Background

The structure of the crew system design process used by USAF Flight Dynamics Laboratory to address the cockpit issues evolves around a mission analysis and composite mission scenario, candidate suites of control/display avionics, and a full-size cockpit mockup. In order to evaluate the candidate suites, fully qualified aircrews fly the composite mission scenario and the candidate avionics suites. Their subjective opinion provide the data base on which to formulate a final design capability of successfully flying the composite mission scenario.

This existing process has two main deficiencies. First, the process relies heavily on subjective preference and inference regarding a crew's capability to manage the allocated tasks with the candidate suite within the context of the composite scenario. Second, the process described above typically costs hundreds of thousands of dollars and several man-years in order to complete a mockup-based evaluation of candidate suites and a full-mission-based simulation validation of the selected suite.

Ideally, the relationship between the candidate controls and displays and the crew task allocation for an aircraft cockpit design being studied should first be defined analytically, and then be evaluated and redesigned as necessary to achieve the optimum expected mission performance. Such analytical evaluation, performed iteratively, would permit the engineer to converge on the optimum avionics suite while the project is still in the "paper study" phase, thereby reducing the more costly mockup evaluation and simulation validation phases to essentially design verification phases with few or no design changes required.

This study employed an analytic method known as the Controls and Displays Evaluation Model, or CODEM. The method, which was developed independently several years ago by Mr. Watler, was computerized at Northrop and has since been applied successfully to several internal company projects.

The CODEM is an analytic design tool which provides a graphical representation of the crew workload predicted for a crew station as a function of the mission, the aircraft, and the controls and displays involved. The CODEM workload profile, which is expressed as a quantitative plot of crew task complexity versus time, is accompanied by a time-correlated printout of each associated control and display task. Unacceptably high workload peaks denoted by the plot can thus be traced back and related directly to the controls and displays causing the overloads. The corresponding corrective design actions under consideration can be tested quickly on the CODEM and assessed for cost and schedule as well as crew performance impacts. The preferred alternative can then be selected on a sound engineering basis and the choice substantiated quantitatively. In other words, the controls and displays can be altered, while still in the early stages of design, to produce predictable changes in crew performance, thereby facilitating the design of the crew station. A more complete explanation of the CODEM and a description of its development is given in Appendix A.

The study relied on design data from the Flight Control Division's Tanker Avionics and Aircrew Complement Evaluation (TAACE). TAACE, which supports the ASD KC-135 Avionics Modernization Program, seeks to establish the design criteria for the controls and displays of the improved flight deck avionics in the event the crew of the KC-135 is reduced by eliminating the navigator.

The TAACE program was a particularly attractive candidate for the first official trial application of the CODEM for two reasons. First, the basic intent of CODEM is to afford exactly the type of evaluation which the TAACE was committed to conduct. Therefore, TAACE could benefit directly from the application of CODEM to its problem. Secondly, the extensive body of empirical data available to TAACE from simulator tests would provide the correlation base necessary for testing the validity of the CODEM predictions.

In the interests of timeliness and economy it was decided to confine the study to the Rendezvous and In-Flight Refueling phase of a representative tanker mission. Further, the study would not attempt to compare the modernized and existing versions of the KC-135 flight deck, but would address only the modernized configuration. The mission scenario and timeline (1) were provided by AFWAL/FIGR personnel along with subsequent explanations and expansions of these mission data, as required.

Objectives

The objective of this study was to evaluate the capability of the tanker flight deck avionics improvements during the Rendezvous and In-Flight Refueling portion of a prescribed mission with a reduced (i.e., pilot and copilot only) flight deck crew. The study involved the analysis of the new flight deck hardware designed for the modernized KC-135; the application of the CODEM computer program to generate crew task complexity, or workload, profiles; and the identification and validation of further avionics changes which, according to the profiles, would further reduce crew workloads.

Prior to this study the new cockpit hardware had been evaluated by the Air Force in a series of simulator tests at Wright-Patterson Air Force Base (WPAFB). These tests confirmed the adequacy of the hardware to meet the dual requirements of modernizing the KC-135 flight deck and of reallocating the flight deck tasks with a view toward eliminating the navigator. This study applied the CODEM to afford a more detailed assessment of the new avionics to the extent that the new elements are involved in the Rendezvous and In-Flight Refueling segment of the mission.

The results of this study are to be used subsequently in a separate effort to validate the CODEM. This validation will be effected by correlating the CODEM predictions for the pilot and copilot in the Rendezvous and In-Flight Refueling segment of the mission to the pilot and copilot performance measurements recorded for the same mission segment during the TAACE simulations conducted previously at WPAFB. It is believed that such a validation will, at least generally, demonstrate the sensibility of the concept as well as the adequacy of the model in terms of its sensitivity and consistency.

(1) AWAL-TR-80-3030, "Tanker Avionics/Aircrew Complement Evaluation (TAACE) Phase Ø - Analysis and Mockup" Volume III, Mission Scenario

SECTION II

APPROACH

Overview of KC-135 Flight Deck Changes

The TAACE design used in this contract was a significant departure from the existing KC-135 system. Major, new, cockpit control and display subsystems were added; old equipment was removed; and important changes were made to crew member responsibilities.

The KC-135 crew station controls and displays arrangement used in this study was developed for the Air Force under another study program. A composite layout of the arrangement is shown in Figure 1. The modified flight deck was designed to accommodate an aerial tanker crew of three--pilot, copilot and boom operator. A navigator station was no longer provided. The navigator's duties were assumed by the copilot and the boom operator with the aid of new navigational equipment, controls, and displays (2).

The basic flight displays were standard round dial instruments plus an oversized flight director indicator. These displays provide both the pilot and the copilot with flight data presentations which were generally the same as those used in present day transport type aircraft.

The flight controls (i.e., rudder pedals, control column, throttle, trim, etc.) of the modernized aircraft were standard KC-135 equipment. The controls were neither moved nor modified.

Probably the most dramatic change to the cockpit was the replacement of the electro-mechanical Horizontal Situation Indicator (HSI) with a Cathode-Ray Tube (CRT) Horizontal Situation Display (HSD), (Figure 1). This device was substituted for the old HSI because it has the flexibility to present a variety of different navigation status information upon command. In some cases, this information is available only to the navigator in the present

(2) AFWAL-TR-80-3030, "Tanker Avionics/Aircrew Complement Evaluation (TAACE) Phase Ø - Analysis and Mockup" Volume I, Results

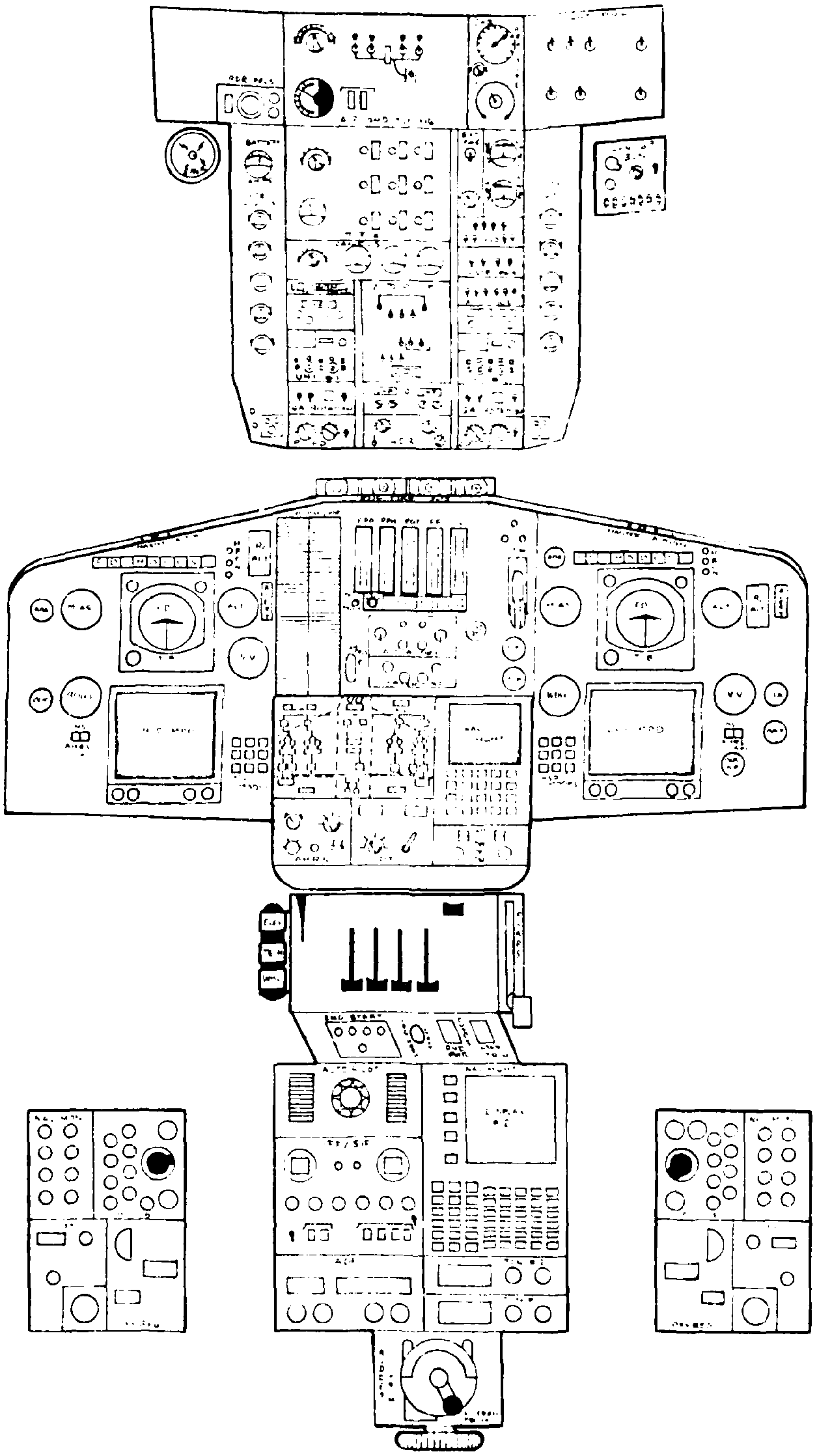

FIGURE 1. MODERNIZED KC-135 COMPOSITE COCKPIT LAYOUT

KC-135. In addition to the basic horizontal situation orientation data, the HSD presents radar information (beacon, ground map, and weather), flight plan routing with map annotation, and rendezvous guidance. These data are selected for presentation through the activation of switches located adjacent to the display. The pilot and copilot's systems have duplicate capabilities.

The HSDs are actually part of a larger control and display subsystem that includes another major cockpit device, the Navigation Management Control Display Unit (CDU). Two of these units are located on the flight deck, both on the center console - one forward of the throttles, on the right-hand side (Figure 1); the other aft of the throttles, also on the right-hand side (Figure 1). Like the HSDs, these units have the same capabilities and can be operated simultaneously. Their primary function is mission planning. After crew insertion of the proper information (waypoint coordinates, temperature, forecast winds, field elevation, planned fuel off-loads, flight planned altitudes, alternates, aircraft weight, etc.), the computer which drives the CDUs, computes Estimated Times of Arrival (ETA), fuel required/ remaining at waypoints, optimum Engine Pressure Ratio (EPR) settings for crew selected profiles, and other data that are not computed manually by either the pilots or the boom operator.

The advanced navigation capabilities provided by the MPD/CDU computer subsystem were believed to embody the heart of a system that would permit the removal of the navigator crew position. Other major changes were made to either physically accommodate the HSDs and CDUs or logically complete the crew system integration started by the HSDs and CDUs.

In the first category (a change made to accommodate the CDUs) is the new fuel panel, (Figure 1). Although very similar in capability to the present system, the new device differs dramatically in appearance. The fuel flow lines illuminate as a function of valve and pump activation; a Center of Gravity (CG) display is provided; fuel quantity is presented digitally; and several caution and warning lights provided notifications associated with varying amounts of fuel remaining.

In the second category (continued integration) are the vertical-scale instruments and the fuel management system. The vertical-scale instruments (Figure 1) take up less instrument panel space and incorporate hydraulic pressure and quantity gauges as well as the usual engine indicators. This

configuration makes it possible for the copilot to monitor hydraulic system performance more completely than before and co-locates similar information (quantities, pressures, and rates) in a centralized position. Also, the vertical-scale instruments are used to indicate EPR values to be flown in order to achieve the fuel consumption profile commanded by the computer subsystem.

Without the navigator onboard, it is belived to be necessary to improve the monitoring of subsystem performance. Thus, another major modification was the installation of an integrated caution and warning system like that found in many other Air Force aircraft, (Figure 1). The Caution and Warning System provides for centralized annunciation of system failures (as well as selected subsystem operating conditions that are not failures) that, in the current tanker, are either not annunciated at all, or are annunciated through lights or other devices scattered throughout the cockpit. Coupled with the master caution lights located on the glare shield in front of each pilot. The new system provides for the required systems monitoring.

Finally, a series of modifications were made to place all critical equipment within arm's reach of at least one pilot. In some cases, this action required only a simple relocating of hardware. The more extensive modifications involved the widening of the aisle-stand aft of the throttles to accommodate additional control heads that must be accessible to both pilots.

<u>Evaluation Scenario</u>

The mission scenario segment used in this study began with the approach to the anchor point prior to refueling and encompassed all events up to and including the boom stowage after refueling was completed. The segment is described as follows:

> Ground Controlled Intercept (GCI) directs or vectors numerous F-15, F-16, A-7, and F-4 tactical aircraft, formations and single ships, to intercept two tankers for inflight refueling. These tactical aircraft are both inbound to and outbound from target areas. Some of the aircraft are required to hold outside the refueling pattern while others are being refueled. Some are extremely low on fuel, requiring coordination for priority treatment. In one case, the

tanker being modeled in the study is required to cut short the anchor and proceed toward a point in the anchor pattern closest to an inbound fighter in an emergency fuel state. The mission is further complicated by the pressures of several weather cells along one side of the anchor which must be circumnavigated.

After approximately 1-1/2 hours in the pattern, enemy fighters attack the formation. A nuclear device is detonated and the tanker sustains an Electro-Magnetic Pulse (EMP). The loss of all non-hardened avionics systems ensues, leaving the tanker without communications and with only limited flight instruments and navigational capability. Most of the electrically operated controls and indicators are inoperative. The boom operator, in the boom pod without his goggles, is blinded by the flash. The tanker, unable to see or communicate with its companion tanker, turns southwestward, dead reckons to a position believed to be over the North Sea and makes a slow spiraling descent to V_{mc} conditions over the water. The tanker then turns northeast and proceeds until landfall on the northwest coast of Denmark. The segment is concluded when the crew chief and the copilot manually stow the boom.

Definition of Crew Tasks with Timelines

The study was organized into three tasks as shown below. Air Force approval of the results of Task 1 was required before work could begin on Task 2.

Task 1: Definition of Crew Tasks with Timelines,

Task 2: Task Complexity Analysis and Coding,

Task 3: Complexity Profiles Generation and Analysis.

The mission scenario of the study effort was defined by the Air Force (3).

TASK 1: Definition of Crew Tasks with Timelines

The Air Force specifically selected the Bodo Contingency Mission from the three mission scenarios detailed in the report, and identified the CODEM modeling block as starting at time 815 (page 121 of the report) and terminating at time 940 (page 140 of the report). The scenario segment

(3) Bunker Ramo Report, No. 4506-020-5100-9, "Tanker Avionics/Aircrew Complement Evaluation (TAACE) Mockup Evaluation Phase" Volume 3, dated June 1979, "Mission Scenario

included all of the tasks and elements discussed in the preceding evaluation scenario section.

From this scenario, Northrop was to develop timeline and detailed, equipment-related, task descriptions of the pilot and copilot functions for the modernized KC-135. The crew task analysis and timelines document was submitted for Air Force review and approval prior to beginning Task 2.

TASK 2: Task Complexity Analysis and Coding

Upon receipt of Air Force approval of Task 1 and the review and resolution of the accompanying Air Force comments, each individual crew task was re-examined and described in more detail, if possible. The detailed task elements were derived from the specific features of the controls and displays equipment elements involved. Next, these elemental sub-tasks were analyzed to establish their respective crew performance times and complexity indices and coded accordingly. The coded tasks and task elements were then loaded into the CODEM computer program data files.

TASK 3: Complexity Profiles Generation and Analysis

Upon completion of the code and load portion of the study, the CODEM computer program was activated to operate on the data files and prepare the corresponding mission files and complexity profiles for the pilot and copilot. The mission files contain all the tasks and task elements involved in the segment of the mission under analysis. These tasks and task elements are provided by the CODEM as time-related task printouts. The complexity plots provide three graphical profiles of task complexity versus time. These profiles are based on peak complexity values determined over intervals of one second, ten seconds and sixty seconds.

The complexity profiles were analyzed to identify specific controls and displays equipment changes which could further reduce the workload of the KC-135 flight deck crew.

The identified changes were then coded and loaded into the CODEM computer program to obtain new complexity profiles incorporating the identified changes. These new complexity profiles afforded a direct comparison of the pilot and copilot workloads with and without the proposed equipment changes.

SECTION III
RESULTS

Crew Task Descriptions and Timelines

Task 1 of the study involved the development of mission timelines and detailed crew task descriptions from data supplied by the Air Force on the mission scenario and the flight deck controls and displays.

The pilot and copilot tasks required to fly and monitor the performance of the modernized KC-135 are not significantly different from those associated with other aircraft in that category. Similarly, the usual display scanning patterns would apply generally to the modified KC-135 cockpit for the segment of the tanker mission under study.

The mission timeline and detailed crew task descriptions for the modernized KC-135 were developed in two parts for each crew member, basal flight tasks and mission-specific scenario events. The basal flight tasks included those elemental tasks that the crew member must perform, repetitively, independent of the mission-specific tasks. The basal tasks thus included functions such as the flying of the aircraft, the monitoring of systems and flight status, the necessary observations outside the aircraft to avoid weather build-ups and other aircraft, and those tasks associated with flight control, position monitoring, and fuel management.

The pilot and copilot basal tasks were organized into sixty second long time blocks. The tasks included in the time blocks were those control and display tasks typically required during the following segments of the mission:

- o Straight and level on anchor track leg (holding altitude and heading and no tow)
- o Straight and level on anchor track leg (holding altitude and heading with refueling aircraft in tow)

- o Turning on anchor track turn leg (holding altitude and maintaining a standard rate turn with no tow)
- o Turning on anchor track turn leg (holding altitude and maintaining a standard rate turn with refueling aircraft in tow).

Accordingly, the pilot basal effort consisted of the following four major tasks: 1) scan outside aircraft to check for weather and other aircraft, 2) scan inside aircraft to check flight instruments and other systems, 3) analyze results to determine flight corrections necessary, and 4) apply control actions to maintain the aircraft on its track. Similarly, the copilot had a basal effort which consisted of the following four major tasks: 1) scan outside aircraft (as backup and support for the pilot), 2) scan inside aircraft (to maintain aircraft status awareness should his takeover be required), 3) analyze results (for this same awareness), and 4) maintain fuel awareness and position keeping. These basal tasks were accomplished continuously throughout the flight unless preempted by higher urgencies or displaced slightly by mission-specific events.

The copilot performed two unique functions during the refueling segment. During that period, his primary responsibility was navigation and his secondary tasks were to provide pilot backup. These tasks must necessarily overlap in time. In the modernized KC-135, the copilot had a navigation computer system at his command. Thus, his navigation tasks principally entailed keeping track of aircraft position in real time relative to the preplanned flight path which he had noted upon a map. System requirements dictated that he make computer position updates from time-to-time.

As the pilot backup, the copilot must stay aware of the flying state of the aircraft. The flying state of the aircraft encompasses the vehicle's attitude in pitch, yaw and roll, and its altitude, airspeed, vertical velocity, heading and course. This duty must be accomplished by regular and frequent crosschecking of the aircraft's flight and power instruments.

The copilot must also be alert to possible outside danger (i.e., weather, other aircraft, the specific and general operational environments, and all enemy-related situations). This duty requires that he maintain a high state of vigilance and respond promptly and appropriately to the visual and aural (radio) stimuli involved.

The mission-specific events identified in the mission scenario included the execution of all flight and inter-aircraft communications; the operations of the fuel panel; the control of the HSD; the operation of the NAV management system; and the accomplishment of those specific, mission-required, control actions such as turns, course adjustment and speed, and altitude changes.

The basic time interval used in developing the crew task descriptions for specific scenario events was derived from the mission scenario (1) provided by the Air Force. The scenario provided minute-by-minute breakdowns of the specific mission events and the majority of the time intervals in the scenario were one minute long. Therefore, the interval of one minute was selected as the basic time interval for the task descriptions. Thus, the mission-specific events and crew functions as well as the basal tasks for both crew members were expressed in terms of one minute time blocks. In the complete body of crew tasks which comprise the total workload, each crew member performed both his basal tasks and his mission-specific tasks. The basal tasks appeared in the CODEM complexity plots as a broad band of general activity. The mission-specific tasks appeared as protuberances on the band of basal tasks.

Each of the pilot and copilot task elements were identified, defined and coded. This detailing of each task element was based on a breakdown of the crew functions into a sequence of individual control-display links that the pilot or copilot had to accomplish in order to fly and maneuver the aircraft. In other words, each task element was itself a control-display link which, in its accomplishment, required a specific time and involved a particular complexity. Each task element typically required the crew member involved to be stimulated by a display or the real world, to receive the information contained in the stimulus, and to perform a control action in response to the information received.

Two opportunities to observe KC-135 flight deck operations were provided. The first took place during the pre-contract period; the second occurred after contract award.

The first observation involved witnessing some of the TAACE simulation evaluations at Wright-Patterson Air Force Base. The mission involved in

(1) AFWAL-TR-80-3030, "Tanker Avionics/Aircrew Complement Evaluation (TAACE) Phase Ø - Analysis and Mockup" Volume III, Mission Scenario

the simulation was different from the mission which was subsequently used as the basis for the contract work. However, the experience was invaluable in providing additional insight into tanker flight deck operations.

The mission used in the observed simulation consisted of a scramble takeoff of two pre-flighted KC-135s to rendezvous with two B-52s for the purpose of in-flight refueling. During the course of the flight, externally-generated conditions which compromised certain capabilities of the mission were simulated. The purpose of the simulation was to assess crew responses to the re-designed cockpit during both normal and degraded aircraft operations.

In the course of the simulation, the crew was required to deal with 1) loss of one tanker aircraft, 2) electrical storms in the refueling corridor, 3) insufficient fuel available to meet incoming aircraft needs, 4) minimum fuel left in the tanker at approach for landing, and 5) failure of two engines during landing approach.

Three observations were recorded relative to crew workload during the simulation:

1) The copilot's workload appeared to be high, principally in the areas of communication, navigation and fuel management.
2) The location of the NAV control keyboard was too far aft for easy access, especially in view of the frequency of its use during refueling. (The forward panel was inoperative as a condition of the scenario.)
3) The moding of the radar was awkward in that both crew members were involved in transferring radar images from one side to the other; however, this was a simulator peculiarity and was not representative of the aircraft.

The second observation of KC-135 cockpit operations was a requirement of the study contract and consisted of an actual KC-135 contingency mission refueling flight out of March Air Force Base at Riverside, California. The mission consisted of a normal, loiter-in-pattern, refueling mission awaiting the arrival of fighters for in-flight refueling. The purpose of the flight was to provide in-flight refueling training for both the tanker crew and the

fighter pilots involved. No unusual flight circumstances such as weather, the approach of unfriendly aircraft, or fuel urgencies interrupted the normal refueling operation. The tanker refueled, at two different times, a total of three F-4 fighters.

The KC-135 flight from March Air Force Base provided an opportunity to witness firsthand and record, by means of video recorders and tape recording audio equipment, the details of a representative tanker mission. As a consequence, the study was started with a better understanding of the elements typically involved in a tanker mission. For example, the study team learned firsthand what was involved in establishing the refueling track, the communications with GCI necessary to coordinate positions, the control of the fighter approaches and contact patterns along with the associated communications, the fuel management functions required during the refueling operation, the handling of fighter disconnections and the related communications requirements, and the dismissal of the fighters from the area after completing the refueling. The video tape and audio recordings were reviewed many times during the development of the mission timelines and the detailed task analysis which followed. The tapes were also helpful in defining the basal flight tasks for both crew members.

The mission timelines and crew task descriptions were submitted to the Air Force upon completion. AFWAL/FIGR arranged for the data to be reviewed and validated by USAF KC-135 crew members. This review and validation fulfilled two critical needs of the study:

1) it established a baseline task analysis and timeline analysis which was mutually acceptable to both the Air Force and Northrop, and
2) it provided the study team with the KC-135 crew member critiques so vital to assure that the workload predictions would be based on realistic crew task descriptions.

The Air Force review of the timeline and task data resulted in minor adjustments to the descriptions. The final Approved Task Descriptions are included in this report as Appendix B. Appendix B also includes the basal task descriptions for both crew members.

Crew Task Complexities (TAACE Design)

Using the approved task descriptions as a starting point, each major task was broken down to the task element level required by the CODEM. For example, the major task of REFUEL RECEIVER AIRCRAFT was reduced to its elemental sub-tasks as follows:

First, the major task was broken down to the sub-tasks of

1) pre-contact communications with the Receiver,
2) contact communications,
3) initiating fuel transfer,
4) keeping track of the fuel offloading,
5) stopping the refueling,
6) disconnection communications, and
7) communicating and recording information on the quantity of fuel offloaded.

Next, these sub-tasks were broken down to their sub-tasks such that INITIATING FUEL TRANSFER, for example, was reduced to the task elements of

a) turning on the aerial refueling valve,
b) verifying that the valve light indicated valve open, and
c) verifying that fuel transfer was occurring.

Every other major task in the revised task description was reduced similarly to its lowest level constituent elements.

Each lowest level task element was further analyzed to determine the time and complexity assignments specifically required for its complete definition. The time requirement was established by either of two methods:

1) simulating and directly timing the task element in question, or
2) going to the human factors literature and/or the Northrop compilation of task times to determine typical timing assignments.

The communications task elements are examples of elements which were directly timed. Those timings were determined either from the recordings made during the KC-135 flight at March Air Force Base or by directly timing the spoken words involved. Operating a refueling valve is one example of a task element which was determined from the human factors literature (4). From the literature, the refueling valve operation was assigned a time allocation of .20 seconds for labeling, .57 seconds for push buttons, .82 seconds due to the number of switches, and .75 seconds for the detenting for a total time of 2.34 seconds. The task complexity index for the refueling valve operation was judged to be a simple conditioned response (i.e., no deliberation required), non-urgent (since it could be delayed a few seconds without serious consequences), and essential (since no fuel would transfer if the operation were not performed). Its complexity was classified accordingly.

A sample CODEM generated Mission Profile for the modernized KC-135 aircraft is shown in Figure 2. The Sixty Second and Ten Second Complexity Plots for the TAACE design, modernized KC-135 aircraft during Rendezvous and In-Flight Refueling are shown in Figure 3 and 4. The TAACE design complexity plots of Figure 3 and 4 reveal no long term overload conditions for either crew member. Further, the plots indicate no exceedances of the Absolute Limit and only one exceedance of the Design Limit (in the Copilot Complexity Plot at time 926). The plots show a number of exceedances of the Design Goal.

The Design Limit exceedance at time 926 for the copilot occurred primarily because the timeline analysis allowed only one minute to accomplish approximately ninety-nine seconds of tasks associated with assessing aircraft damage after the EMP strike. If the tasks squeezed into those sixty seconds could have been spread out over, say, the next sixty seconds as needed to complete the necessary damage assessment, tests, and checks in a timely but less hurried fashion, the Design Limit exceedance would not have occurred. This was demonstrated by the CODEM design Sixty Second and Ten Second Copilot Complexity plots of Figure 3 in which the copilot tasks following the EMP were permitted to run to time 927. The exceedances of the

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(4) "An Index of Electronic Equipment Operability - DATA STORE", Report No. AIR-C43-1/62-RP (1), prepared by the Signal Corps.

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                                  ** RAX370 BATCH PRINT **
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3 1   0   0    0            PROCEED TO ANCHOR POINT                     0. 0 000
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                900100  5           TIME AVERAGED OUTSIDE SCAN          9.14 212
0 0   0  08003                     SCAN INSIDE AIRCRAFT                24 71 000
                800100  1           TIME AVERAGED INSIDE SCAN          24.71 212
0 0   0  01414                     ANALYZE RESULTS                      5 37 000
                140100  9           TIME AVERAGED ANALYSIS              5.37 212
0 0   0  08716                     APPLY CONTROL ACTION                30 36 000
                870100  1           TIME AVERAGED CONTROL ACTIONS      30.36 212
99 1: 0   0 881                                                         1. 0 000
3 1 10    0    0              REVIEW CREW PROCEDURES 0815               0. 0 000
0 0   0  02300                     COMM PILOT/COPILOT          0815     8 81 000
                238150 51           P - TURN TO ANCHOR DOWNWIND         8.17 222
                238150 52           CP - ROGER                           .64 222
0 0:  0  06958                                                          1. 0 000
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0 0   0  09008                     SCAN OUTSIDE AIRCRAFT                9 14 000
                900100  5           TIME AVERAGED OUTSIDE SCAN          9.14 212
0 0   0  08003                     SCAN INSIDE AIRCRAFT                24 71 000
                800100  1           TIME AVERAGED INSIDE SCAN          24.71 212
0 0   0  01414                     ANALYZE RESULTS                      5 37 000
                140100  9           TIME AVERAGED ANALYSIS              5.37 212
0 0   0  08716                     APPLY CONTROL ACTION                30 36 000
                870100  1           TIME AVERAGED CONTROL ACTIONS      30.36 212
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3 1 20    0    0              PREP FOR CONTACT CHECKLIST                0. 0 000
3 1 20100      0               CHECKLIST AT 0816                        0. 0 000
0 0   0  09621                     CHECKLIST-ALTIMETER                  5 12 000
                238160 61           CP - ALTIMETER SET                  2.52 212
                140700  4           SET ALTIMETER TO 29.92              2.60 212
0 0   0  09602                     CHECKLIST-RADAR BEACON               2 33 000
                238160 62           CP - RADAR BEACON OPERATE           2.33 212
0 0   0  09623                     CHECKLIST-STABILIZER TRIM           13 36 000
                238160 63           CP - STABILIZER TRIM                1.36 212
                130200  1           STABILIZER TRIM MANUAL              9.02 222
                130200  2           STABILIZER TRIM ELECTRIC            2.98 222
0 0   0  09624                     CHECKLIST-AUTOPILOT TRIM            16 65 000
                238160 64           CP - AUTOPILOT STABILIZER TRIM      2.59 212
                310100  1           AUTOPILOT TRIM FOLLOWUP            14.06 212
0 0:  0  06958                                                          1. 0 000
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Figure 2. Sample Mission Profile

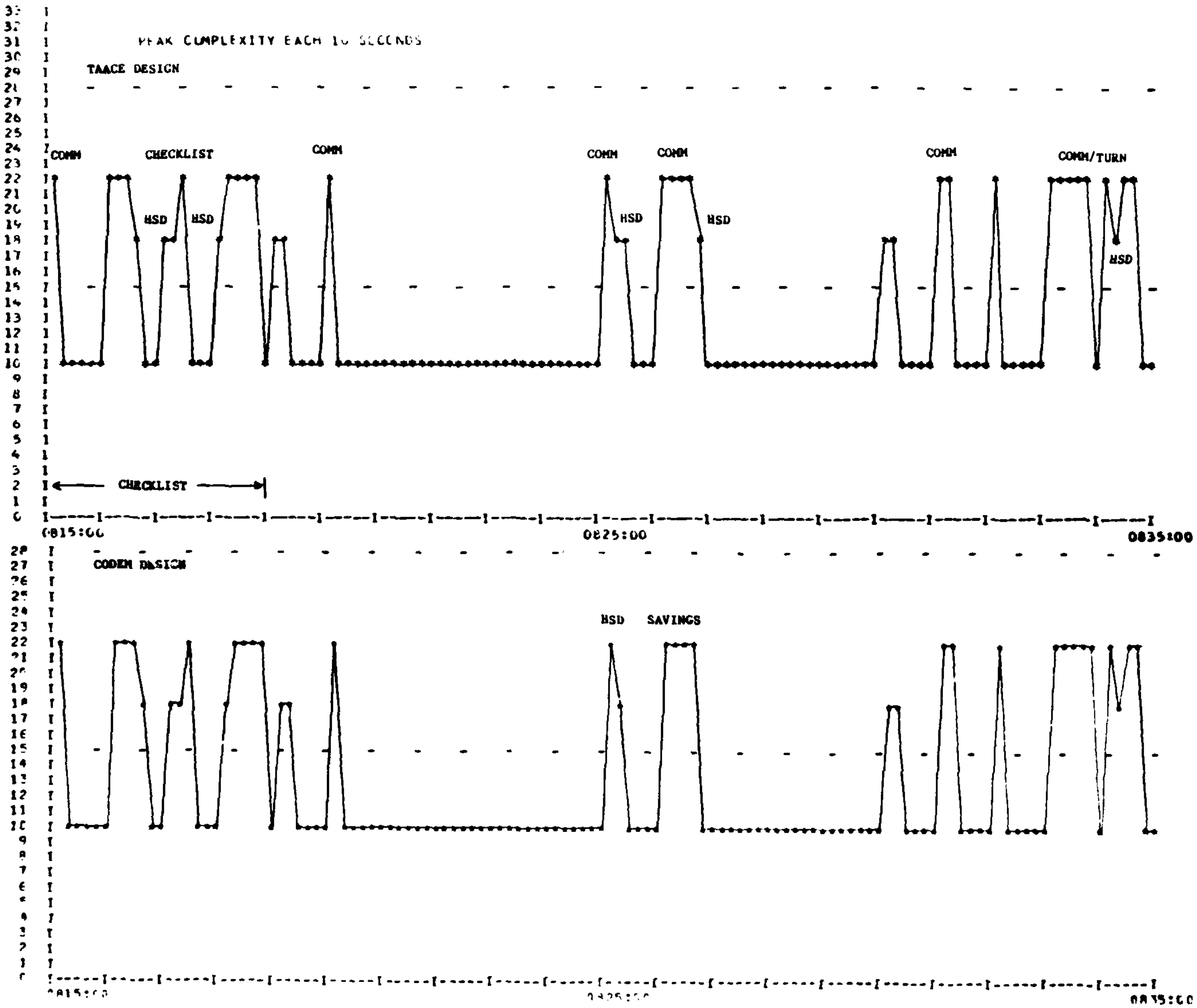


Figure 3. Ten Second Pilot Complexity Plot (Sh 1 of 5)

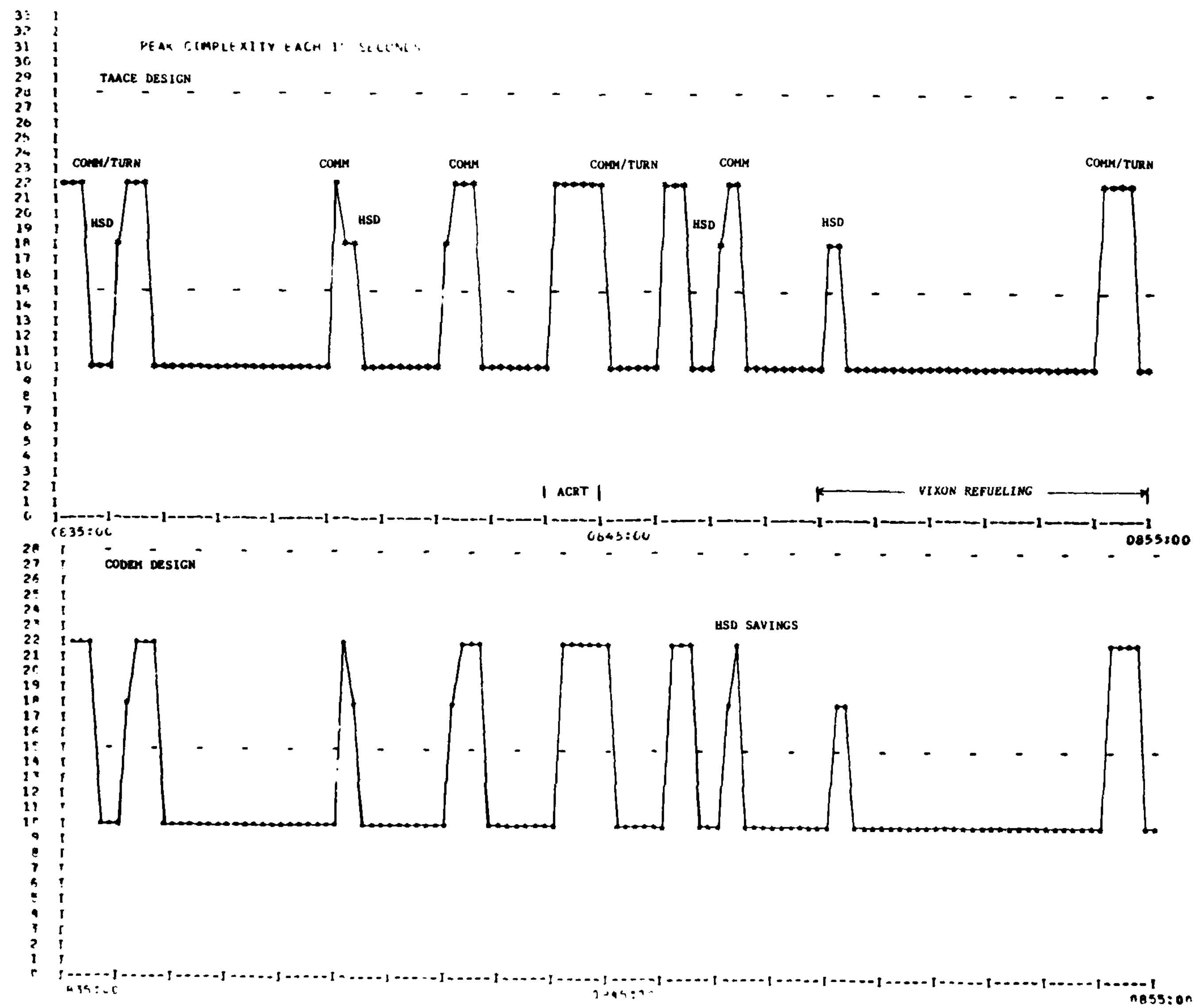


Figure 3. Ten Second Pilot Complexity Plot (Sh 2 of 5)

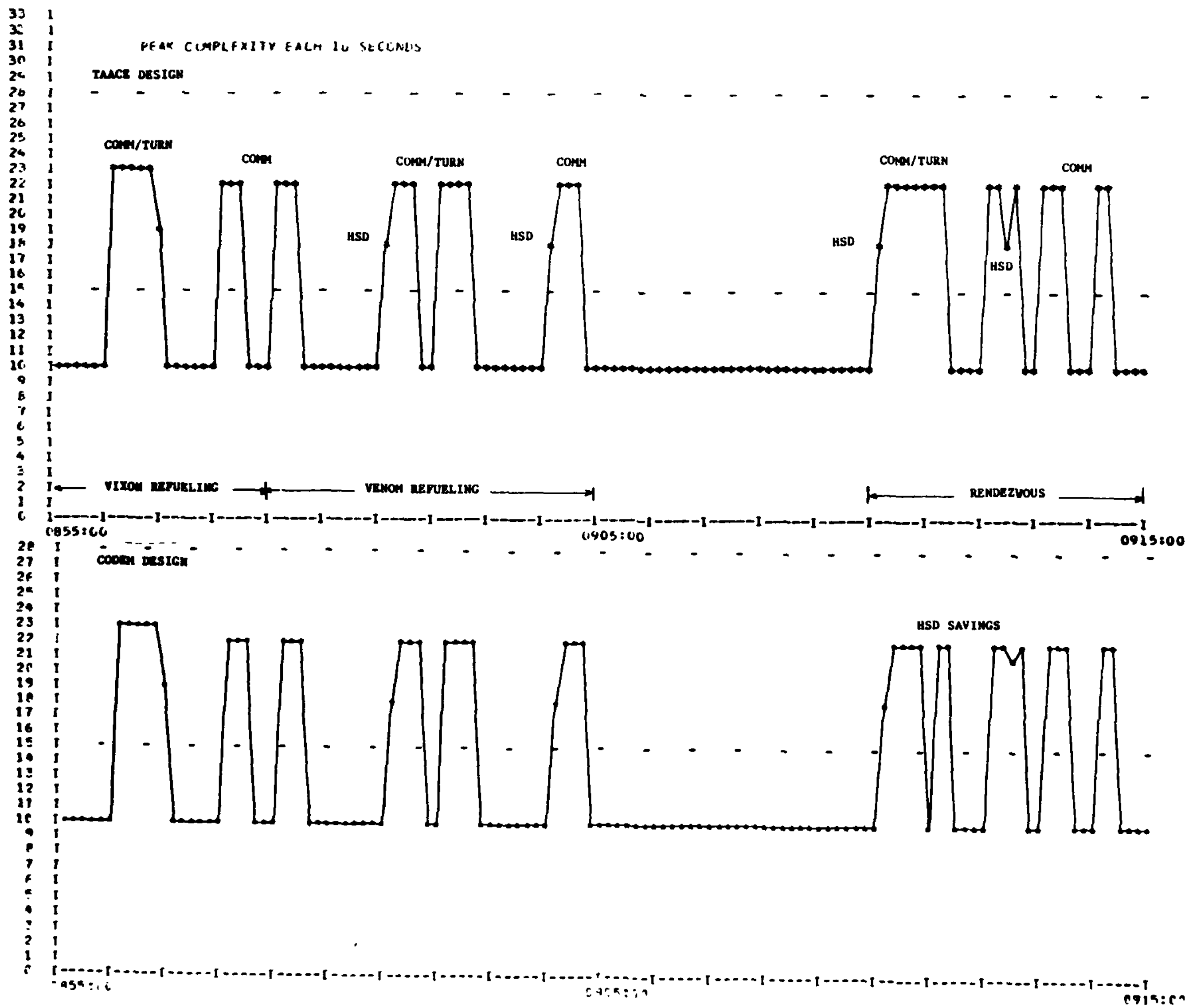


Figure 3. Ten Second Pilot Complexity Plot (Sh 3 of 5)

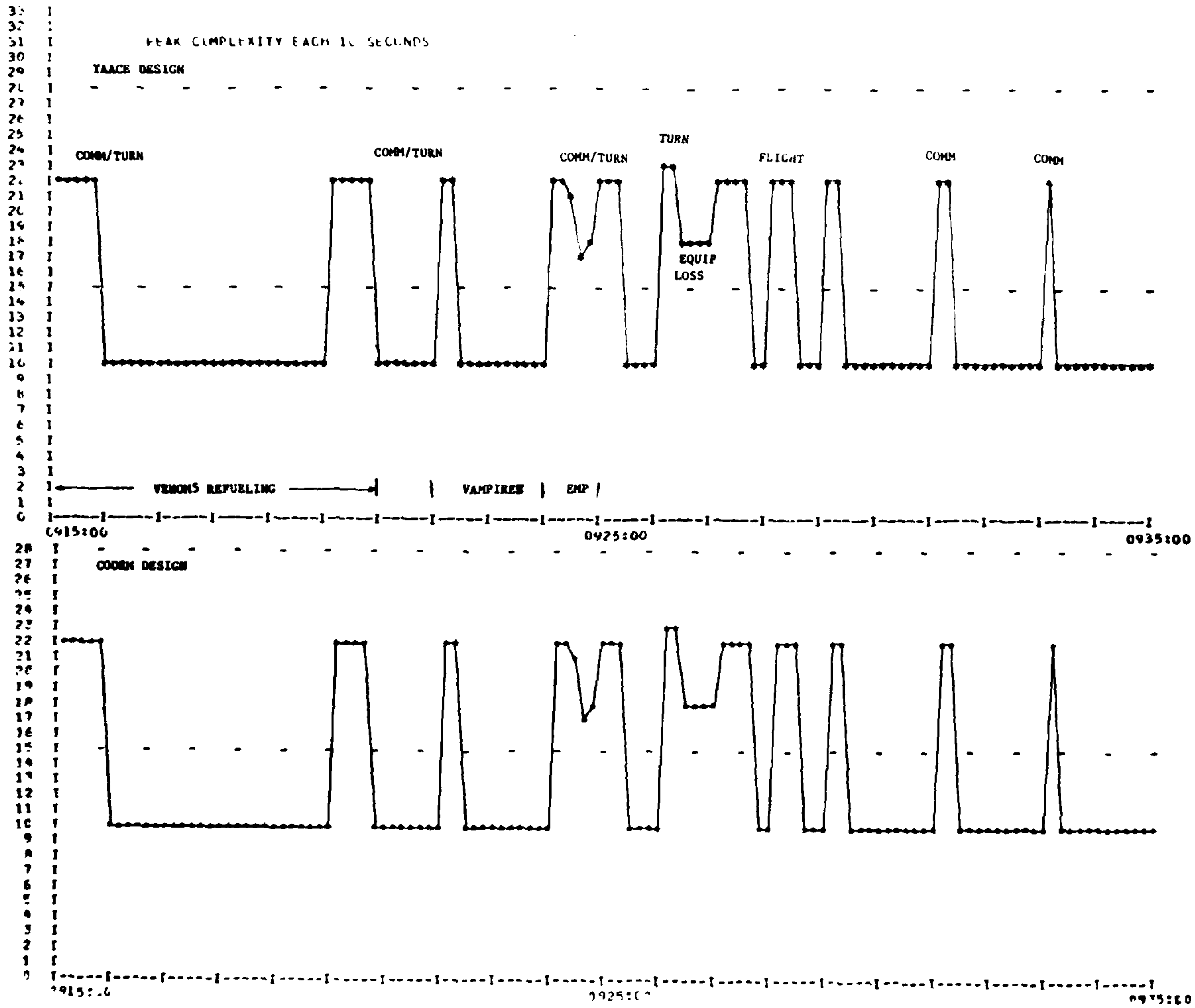


Figure 3. Ten Second Pilot Complexity Plot (Sh 4 of 5)

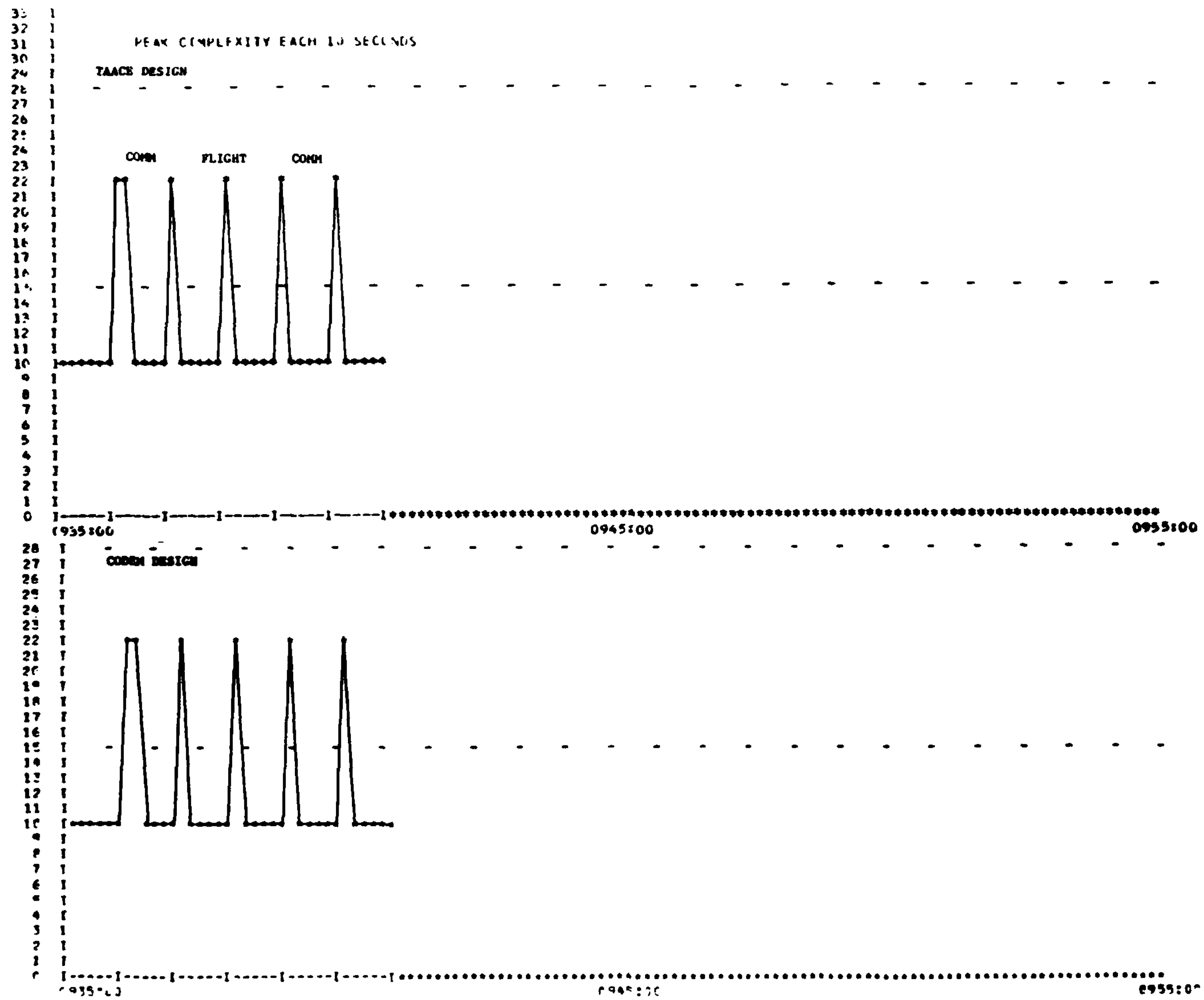


Figure 3. Ten Second Pilot Complexity Plot (Sh 5 of 5)

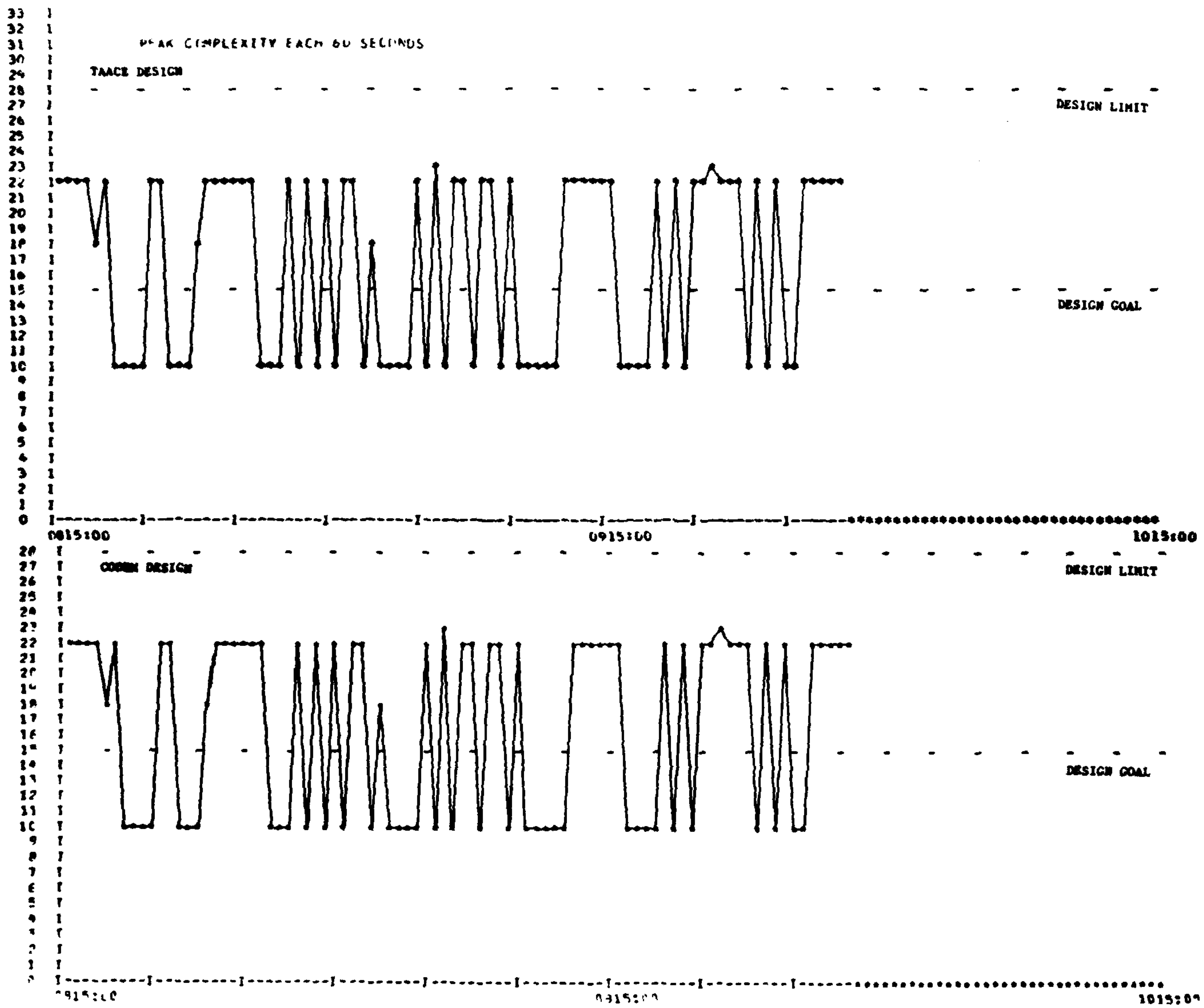


Figure 4. Sixty Second Pilot Complexity Plot

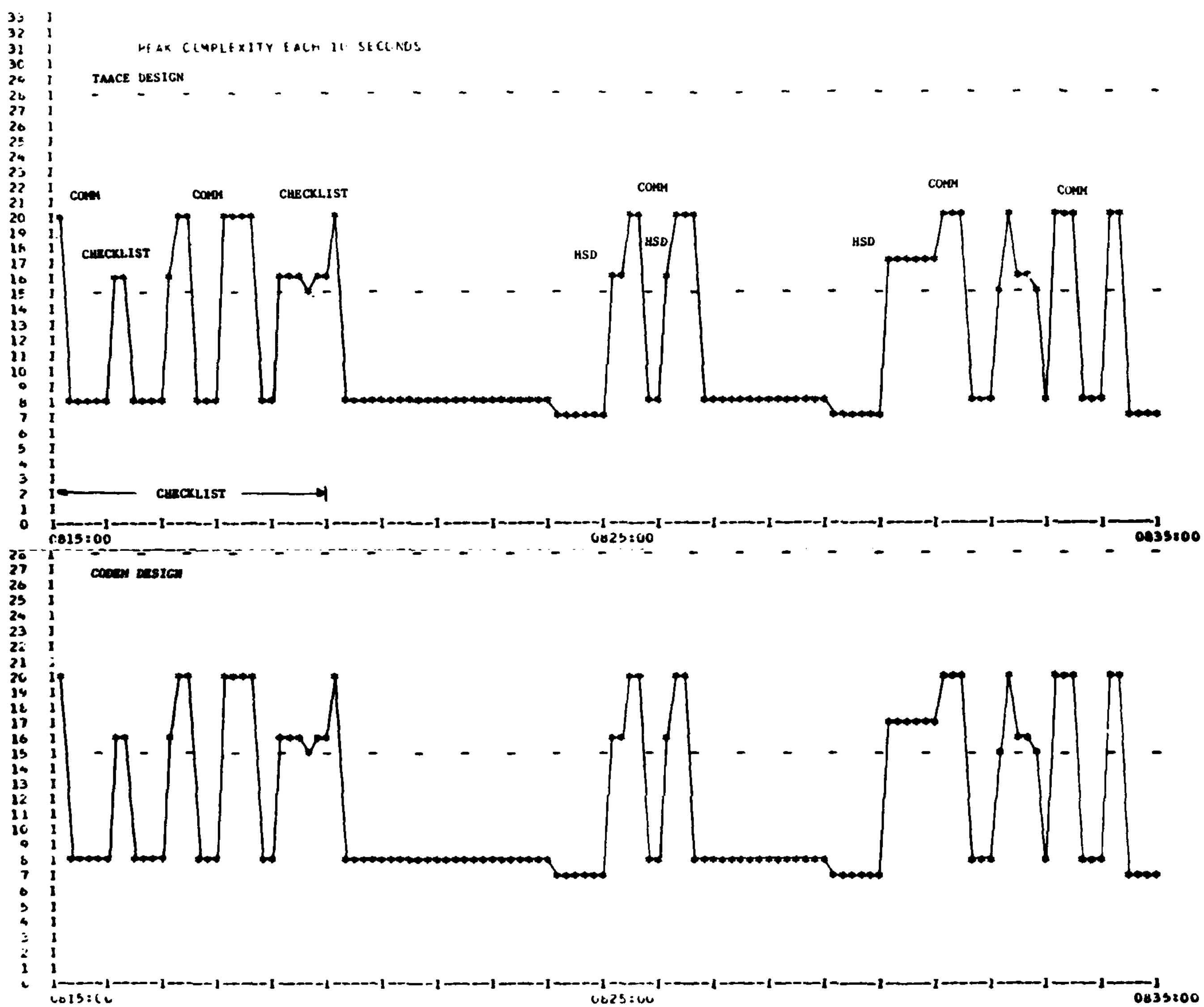


Figure 5. Ten Second Copilot Complexity Plot (Sh 1 of 5)

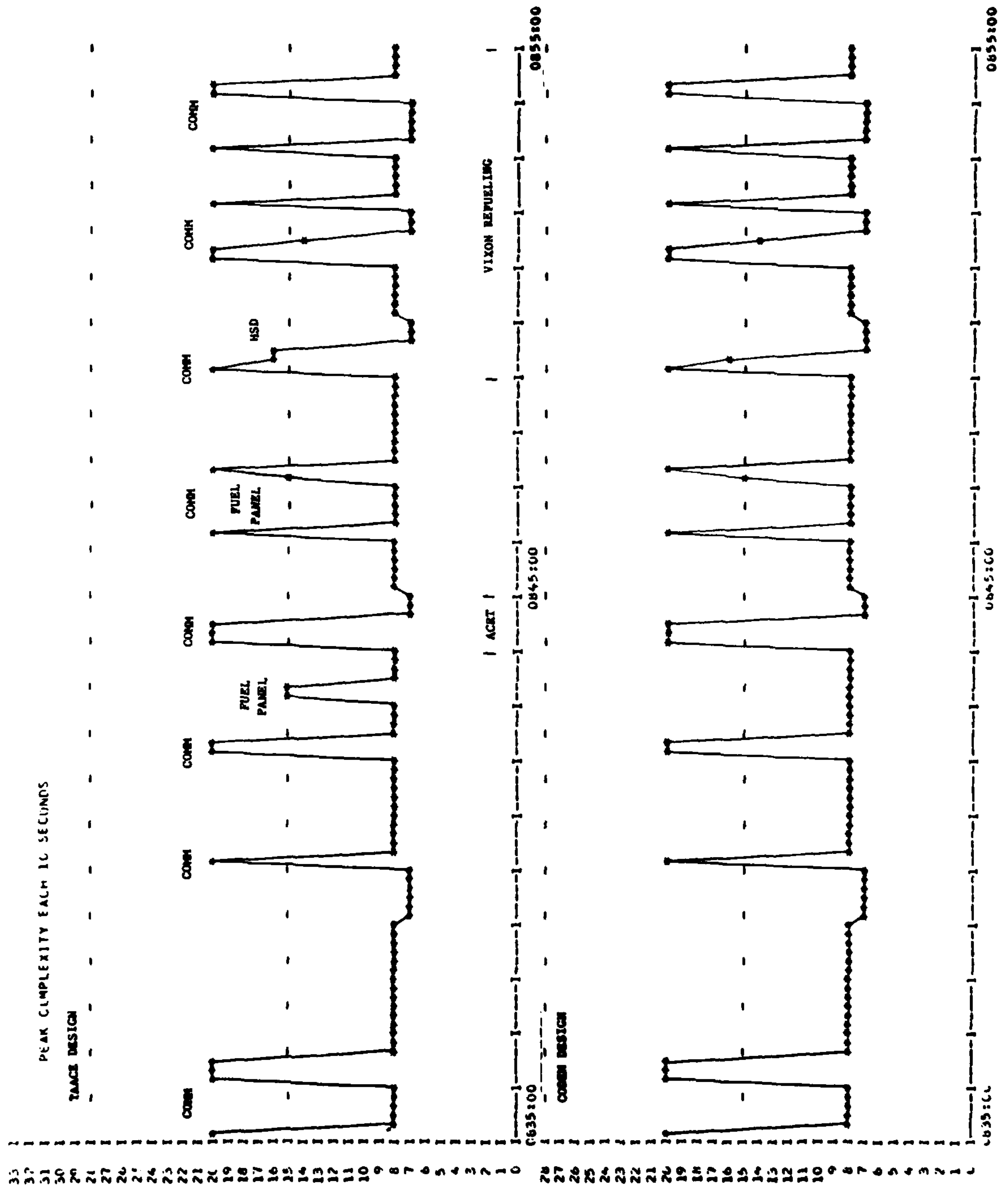


Figure 5. Ten Second Copilot Complexity Plot (SH 2 of 5)

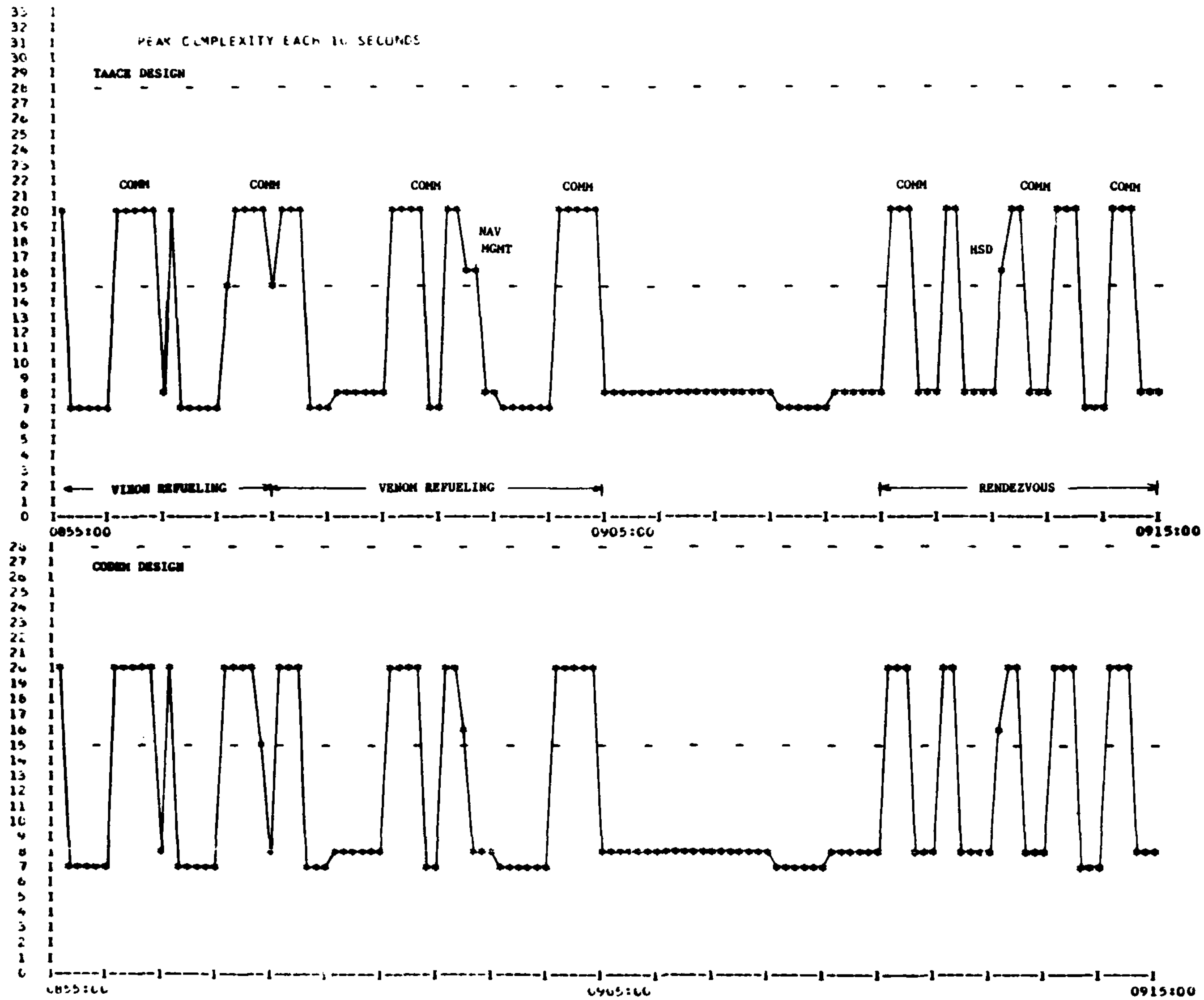


Figure 5. Ten Second Copilot Complexity Plot (Sh 3 of 5)

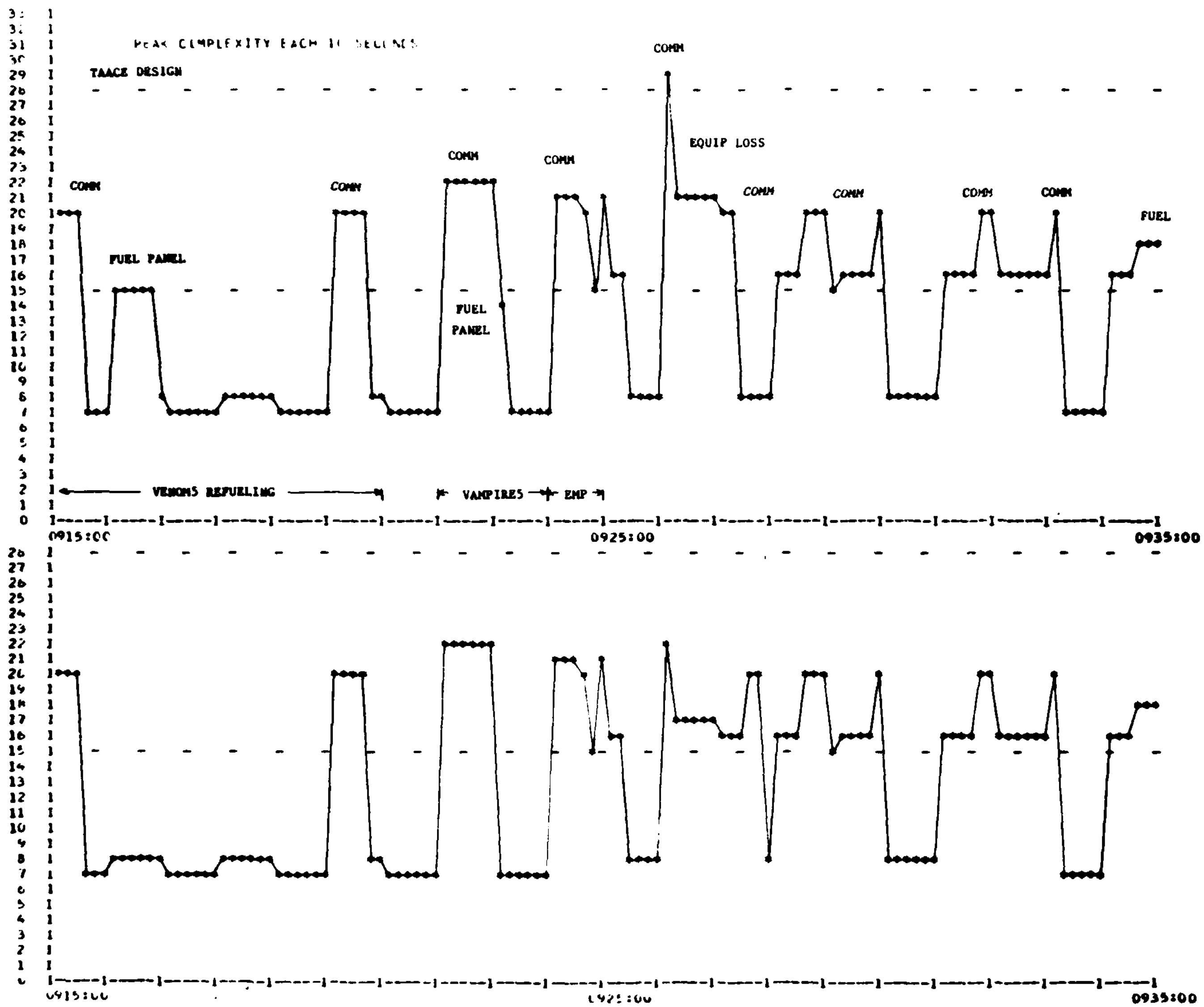


Figure 5. Ten Second Copilot Complexity Plot (Sh 4 of 5)

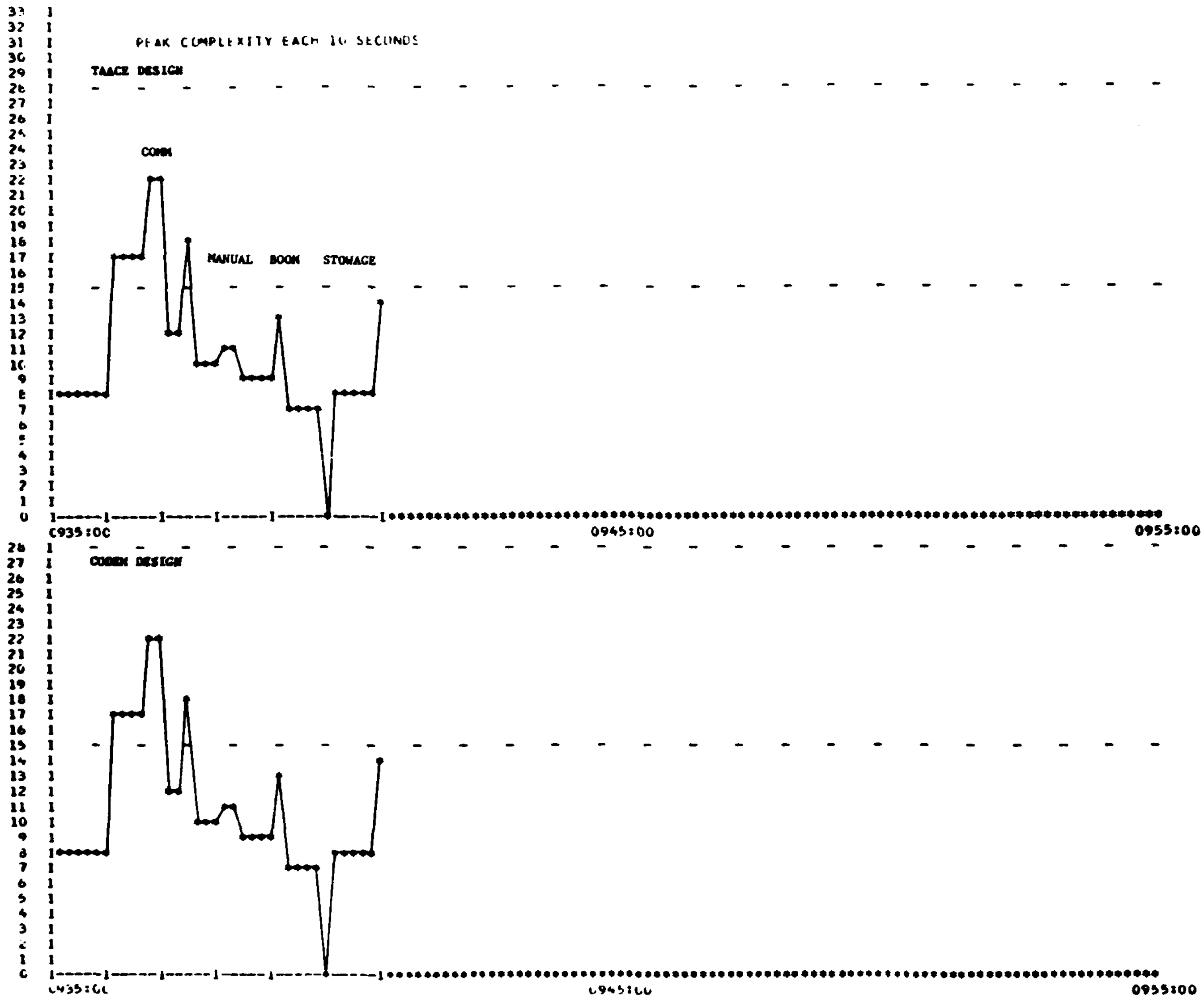


Figure 5. Ten Second Copilot Complexity Plot (Sh 5 of 5)

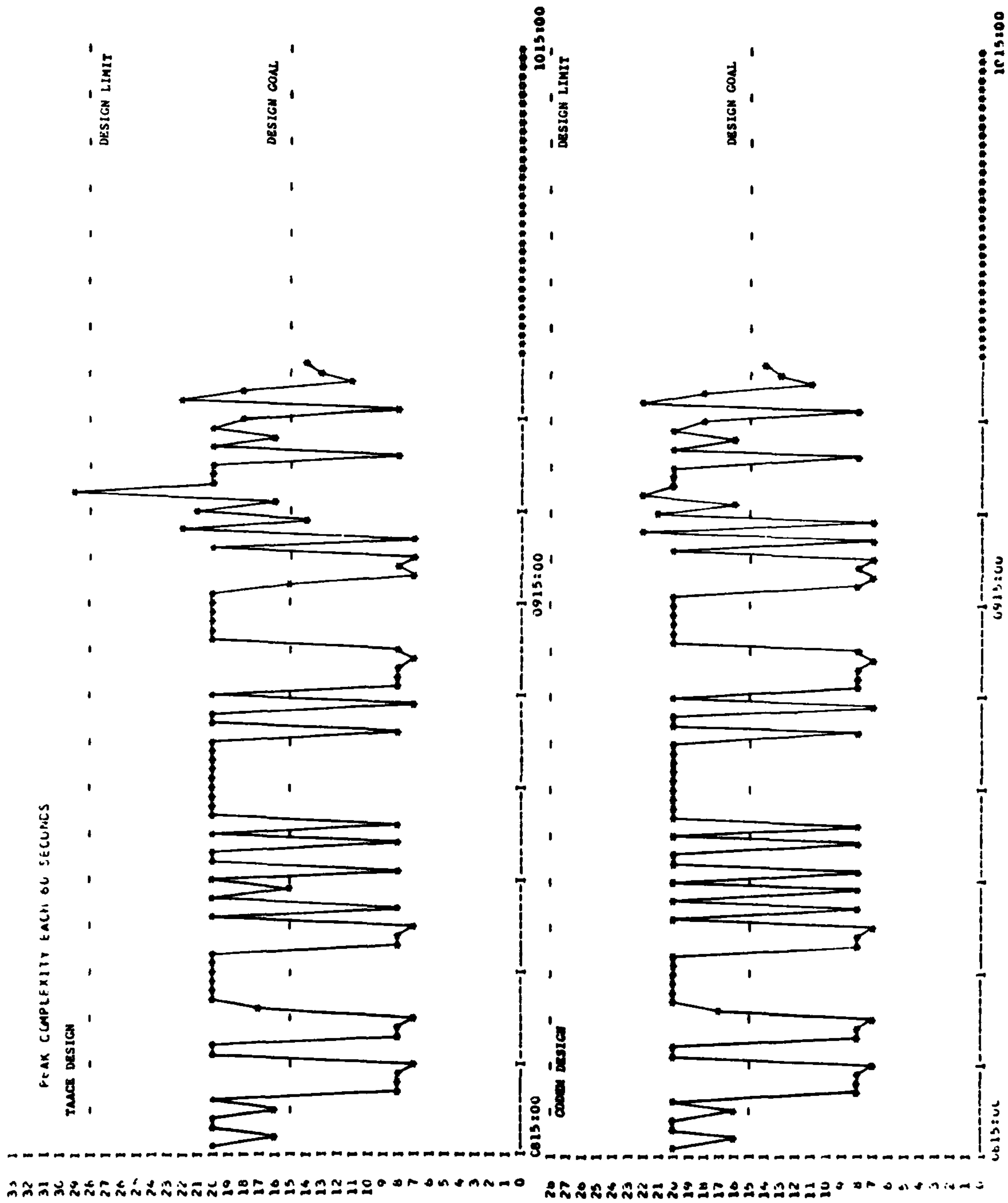


Figure 6. Sixty Second Copilot Complexity Plot

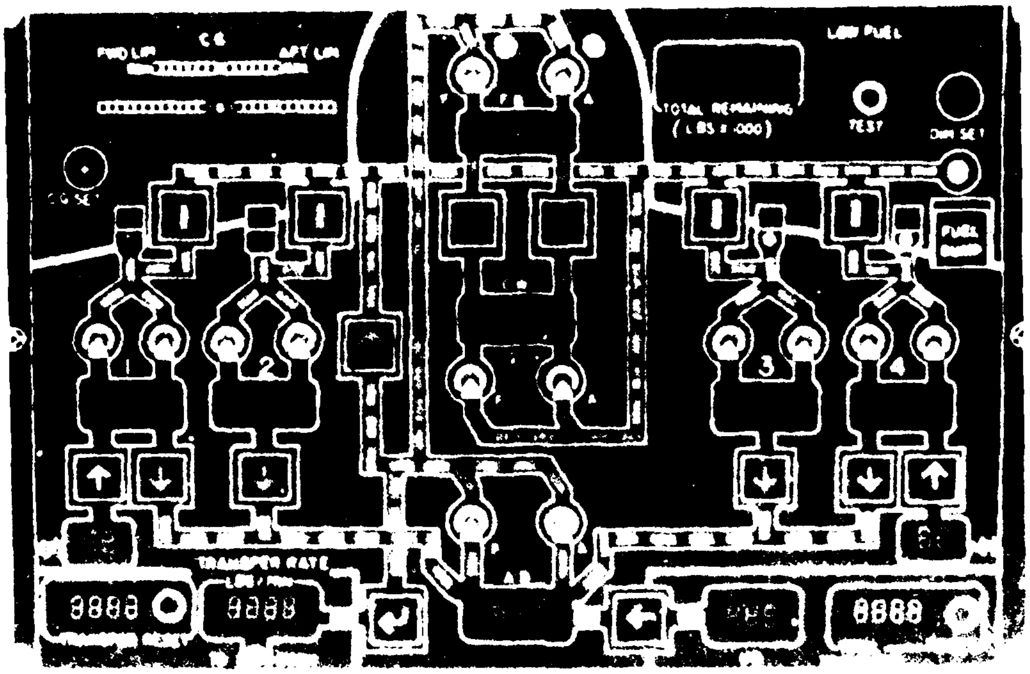
Design Goal, though numerous, are not regarded with concern in that they are not extreme, they are primarily the results of communications traffic, and they are interspersed evenly with periods of relatively low workloads.

Crew Task Complexities (CODEM Design)

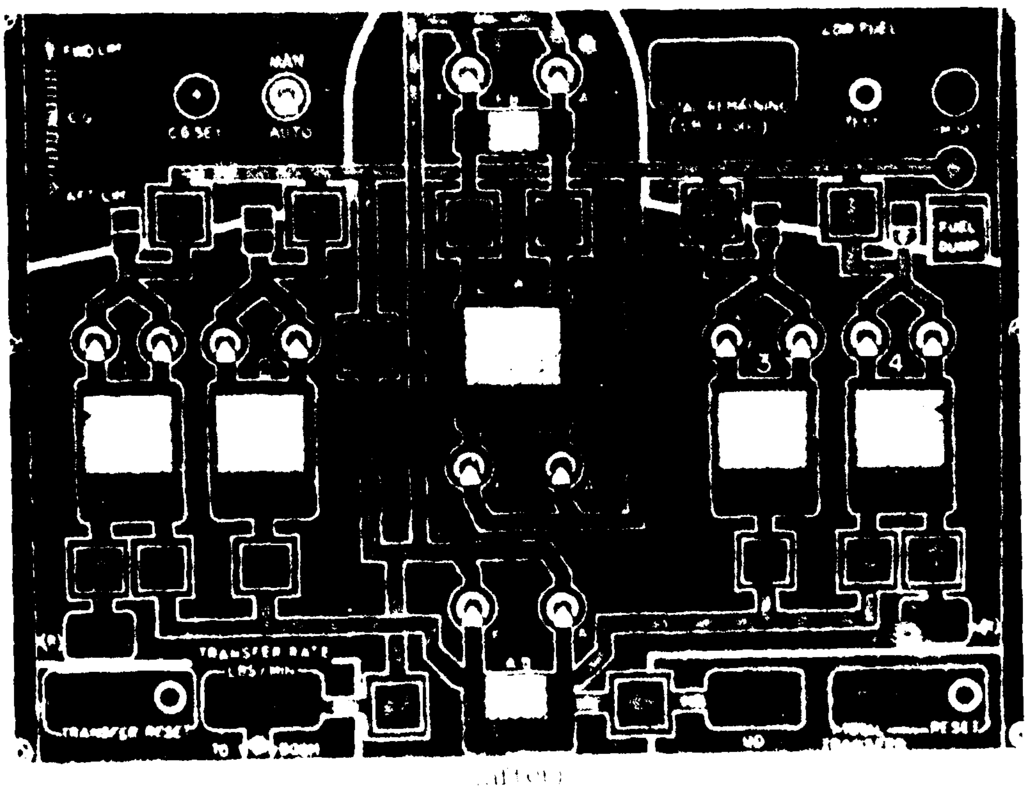
The complexity plots for the TAACE design modernized KC-135 aircraft of Figure 3 and 4 showed that neither crew member was overloaded during the Rendezvous and In-Flight Refueling portion of the BODO contingency mission. On that basis, therefore, the new avionics equipment items involved in that segment of the mission do not appear to be contributing adversely to crew workload. Nevertheless, three of the new flight deck avionics equipment items (namely, the FUEL CONTROL PANEL, the HORIZONTAL SITUATION DISPLAY, and the NAV MANAGEMENT SYSTEM PANEL) which played a significant part in the refueling portion of the mission were evaluated in more detail. This evaluation was undertaken in the interest of identifying any changes which could improve these equipments in the event they are used in other aircraft and/or missions where their designs might prove to be critical. In each case, some improvement changes were identified and are recommended. These changes have resulted in reduced time/complexity characteristics for each equipment. The proposed improvements were input to the CODEM which generated the CODEM design Ten and Sixty Second Pilot and Copilot Complexity Plots (shown in Figure 3 and 4) Again, none of the recommended improvements were critically necessary in the operational context of the modernized KC-135 which was studied. Rather, they were included in this report because they were a normal by-product of the study, and they serve to demonstrate both the value of a quantitative controls and displays design methodology and the capability of the CODEM in that regard. The recommended changes are described individually in the discussions which follow.

RECOMMENDED CHANGES TO THE FUEL CONTROL PANEL

The new FUEL CONTROL PANEL shown in Figure 5 featured a number of improvements over the old KC-135 FUEL CONTROL PANEL. Color was used to distinguish fuel flow paths; digital readouts were used to provide more display accuracy; and a microprocessor was used to drive the display, its



(BEFORE)



(AFTER)

FIGURE 5. FUEL CONTROL PANEL

readouts, lights, and a center of gravity scale. The panel provided visual information which identified the tanks that were active in supplying engine fuel as well as those involved in meeting refueling demands. The crew tasks associated with the operation of the new FUEL CONTROL PANEL are listed in Table 1.

Three areas of improvement for the FUEL CONTROL PANEL were identified during the evaluation portion of the contract:

1) Fuel Management

The management of fuel distribution is a function of weight distribution, aircraft center of gravity, and flight mode. The required fuel distribution is tabulated in the KC-135 flight manual by weight and flight mode and could easily be memorized by the panel's microprocessor. Addition of an auto/manual switch would allow the microprocessor to manage fuel distribution automatically in accordance with the required schedule with reversion to manual means when desired. This change would eliminate Tasks 1701, 1702, 1703, 1704, 1706, 1707 and 1709 and result in attendant reductions in the crew workload. Figure 6 shows a one second complexity plot depicting the deletion of tasks 1703 and 1709 at 843.

2) Fuel Level Displays

The addition of pictorial fuel tank level displays to the panel would facilitate crew determination of "order of magnitude" fuel status. The crew member will require some means of assessing the fuel distribution state at a glance, whether or not the function is being performed automatically. This change would effect a small reduction in Task 1805, FUEL AWARENESS. (Note: the digital readouts would remain and would be used when exact quantities are required.)

3) Center of Gravity CG) Display

The CG Scale would be more effective if it were oriented in the direction of the imbalance rather than athwartships.

These three improvements (shown in Figure 5) are included in the CODEM design Ten and Sixty Second Copilot Complexity Plots (Figure 3). The changes afford workload reductions at times 843, 858, 916, and 923 as well as a reduction in the copilot's basal task of FUEL AWARENESS.

TABLE 1. FUEL PANEL TASKS
(Sheet 1 of 3)

Task 1701 Applicable At Time 916*

01701			Select Refueling From Main Tnks	31 61	000
	180701	1	Read Tank FB Quantity Indicator	1.80	112
	171601	1	Turn Tank 1 to AB Valve On	2.34	112
	183701	1	Verify Tank 1/R Valve SW LTD	1.95	112
	182301	1	Verify Tank 1/AB Mani SEG LTD	1.95	112
	171701	1	Turn Tank 2 to AB Valve On	2.34	112
	183801	1	Verify Tank 2/R Valve SW LTD	1.95	112
	182501	1	Verify Tank 2/AB Mani SEG LTD	1.95	112
	171801	1	Turn Tank 3 To AB Valve On	2.34	112
	183901	1	Verify Tank 3/R Valve SW LTD	1.95	112
	182501	1	Verify Tank 3/AB Mani SEG LTD	1.95	112
	171901	1	Turn Tank 4 To AB Valve On	2.34	112
	184001	1	Verify Tank 4/R Valve LTD	1.95	112
	182601	1	Verify Tank 4/AB Mani SEG LTD	1.95	112
	170701	1	Turn FWD REF Pump On Tank AB	1.45	112
	170701	2	Turn AFT REF Pump On Tank AB	1.45	112
	182901	1	Verify AB/REF Mani SEG LTD	1.95	112

Task 1702 Applicable At Time 923*

01702			Select Reserve Tanks On	8 58	000
	172001	1	Turn Tank 1R To No 1 valve On	2.34	112
	172101	1	Turn Tank 4R To No 4 Valve On	2.34	112
	183501	1	Verify Tank 1R/1 Valve SW LTD	1.95	112
	183601	1	Verify Tank 4R/4 Valve SW LTD	1.95	112

Task 1703 Applicable At Time 843*

01703			Select Refueling From FB	6 65	000
	180701		Read Tank FB Quantity Indicator	1.80	112
	170601	1	Turn FWD REF Pump On Tank FB	1.45	112
	170601	2	Turn AFT REF Pump On Tank FB	1.45	112
	182801	1	Verify FB/REF Mani SEG LTD	1.95	112

Task 1704 Applicable At Time 916*

01704			Deselect Refueling From FB	6 65	000
	180701		Read Tank FB Quantity Indicator	1.80	112
	170601	3	Turn FWD REF Pump Off Tank FB	1.45	112
	170601	4	Turn AFT REF Pump Off Tank FB	1.45	112
	182801	2	Verify FB/REF Mani SEG Dark	1.95	112

*See notes on sheet 3.

TABLE 1. FUEL PANEL TASKS
(Sheet 2 of 3)

Task 1705 Applicable At Time 847

01705		Check Refueling From FB	3 75	000
180701		Read Tank FB Quantity Indicator	1.80	112
182801	1	Verify FB/REF Mani SEG LTD	1.95	112

Task 1706 Applicable At Time 858*

01706		Select Refueling From CW	10 38	000
190801		Read Tank CW Quantity Indicator	1.80	112
172201	1	Turn CW To FB Valve On -L	2.34	112
172201	2	Turn CW To FB Valve On -R	2.34	112
184201	1	Verify TNKCW/FB Valve SW LTD L	1.95	112
184201	2	Verify TNKCW/FB Valve SW LTD R	1.95	112

Task 1707 Applicable At Time 916*

01707		Deselect Refueling From CW	10 38	000
180801		Read Tank CW Quantity Indicator	1.80	112
172201	3	Turn CW To FB Valve OFF-L	2.34	112
172201	4	Turn CW To FB Valve OFF-R	2.34	112
184201	3	Verify TNKCW/FB Valve SW Dark L	1.95	112
184201	4	Verify TNKCW/FB Valve SW Dark R	1.95	112

Task 1709 Applicable At Time 843*

01709		Deselect Refueling From AB	6 65	000
180901		Read Tank AB Quantity Indicator	1.80	112
170701	3	Turn FWD REF Pump OFF Tank AB	1.45	112
170701	4	Turn AFT REF Pump OFF Tank AB	1.45	112
182901	2	Verify AB/REF Mani SEG Dark	1.95	112

Task 1710 Applicable At Time 849, 853, 857, 901, 915, 922

01710		Refuel Receiver Aircraft	6 34	000
172401	1	Turn AR Line Valve ON	2.34	112
184101	1	Verify Refuel Valve SW LTD	1.95	112
181301		Read Transfer Rate Indicator	2.05	112

Task 1711 Applicable At Time 851, 855, 858, 904, 920, 924

01711		End Refuel Receiver Aircraft	4 29	000
172401	2	Turn AR Line Valve OFF	2.34	112
184101	2	Verify Refuel Valve SW Dark	1.95	112

*See notes on sheet 3.

TABLE 1. FUEL PANEL TASKS
(Sheet 3 of 3)

Task 1712 Applicable At Time 851, 858, 904, 920, 924

01712		Record Transferred Quantities	10 4	000
181301		Read Transfer Rate Indicator	2.05	112
181401		Read Transfer Quantity IND	2.05	112
181501		Record Fuel Quantity	3.00	212
170901		Reset Transfer Quantity	.89	112
181401		Read Transfer Quantity IND	2.05	112

Task 1713 Applicable At Time 911

01713		Checks Fuel Panel	5 70	000
184801		Read Tank CW Quantity Indicator	1.80	112
184201	1	Verify TNKCW/FB Valve SW LTD L	1.95	112
182801	1	Verify FB/REF ManI SEG LTD	1.95	112

Task 1802 Applicable At Time 847

01802		Reset Refueling Panel Gauges	6 8	000
170901	1	Reset Transfer Quantity	.89	112
181401		Read Transfer Quantity IND	2.05	112
170901	2	Reset Total Transfer	1.09	112
181201		Read Total Transfer Indicator	2.05	112

Task 1805 Applicable To BASAL Task

01805		Fuel Awareness	11 50	000**
181900	1	Time Average Fuel Awareness	11.50	112**
		Read Total Fuel Quantity		
		Read Center of Gravity Scale		
		Evaluate Fuel Distribution		

NOTES:

*This task deleted entirely on CODEM design.

**Time becomes 11.00 in CODEM design.

ABBREVIATIONS:

AB - Aft Body
AR - Aerial Refueling
CW - Center Wing
FB - Forward Body
LTD - Lighted
Mani - Manifold
REF - Refueling
SEG - Segment
SW - Switch
TNKCW - Tank Center Wing

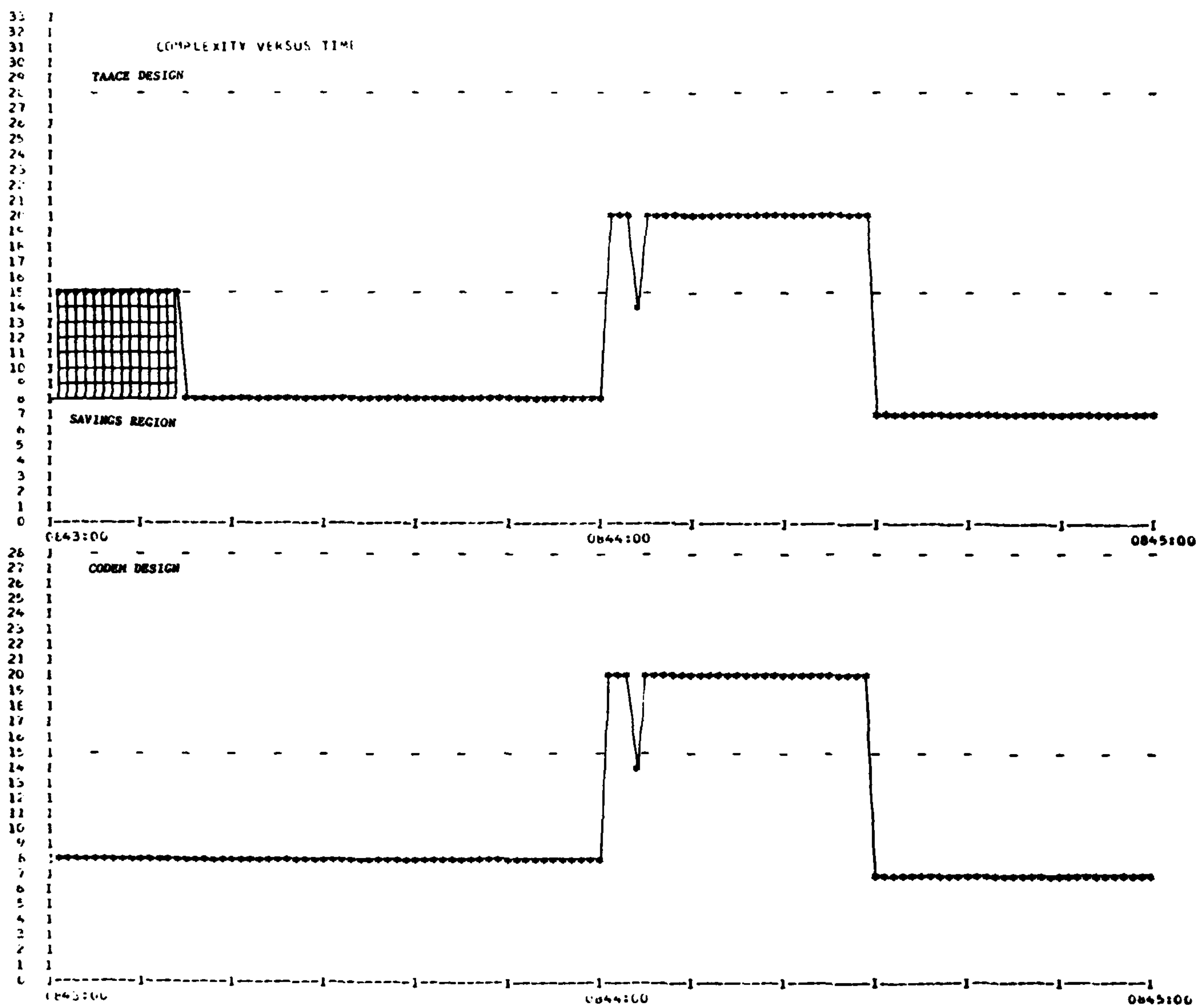
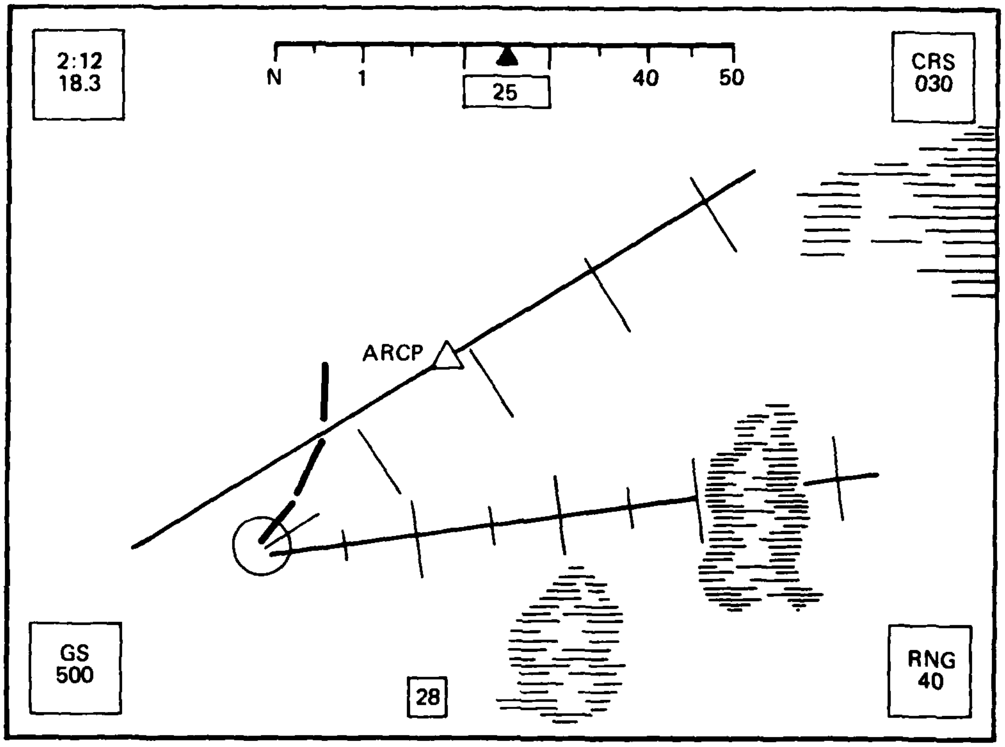


Figure 8. One Second Complexity Plot - Fuel Panel Savings

RECOMMENDED CHANGES TO THE HORIZONTAL SITUATION DISPLAY FORMATS

The Horizontal Situation Display (HSD) was a new item for the KC-135. The HSD multi-function concept allows the pilot to select for presentation on the HSD any of a number of different formats. Thus, with but one display, any of the HSD information items of interest can be called up for presentation. The display presented, in stroke-written form, computer generated formats such as the Horizontal Situation Indicator (HSI), moving maps, holding and rendezvous patterns, weather radar returns, and ILS patterns. In addition, the HSD provided the means to overlay on one another certain of these displays. Typical examples of the HSD formats are shown in Figures 7 (map with weather radar), 8 (weather radar), 9 (holding pattern with radar), 10 (map alone) and 11 (rendezvous). These display presentations depict the aircraft with the appropriate track and planned course lines, ground speed, range of display, and time and distance to an external reference. The majority of these data are presented around the periphery of the display. The crew tasks associated with the operation and observation of the HSD are identified in Table 2. Two minor changes in the formats are suggested. These changes will modify the presentation slightly and reduce the time necessary to scan the display and interpret the information. The suggested changes are as follows:

1) The circle with a line through it which is used to depict the aircraft should be replaced with an actual plan form of the aircraft pointing in the direction of flight. This change would provide a more rapidly identifiable symbol, especially important in a more cluttered display or during a period of high crew workload or stress.
2) The course, heading, speed, distance and time should be moved from the periphery of the display to points on the display proper which are more directly related to the data involved. For example, the speed and direction information should be placed in the immediate area of the aircraft symbol, the course numerics should be located beside the course line, and the time and distance information should be displayed next to the point on the map to which the information relates.



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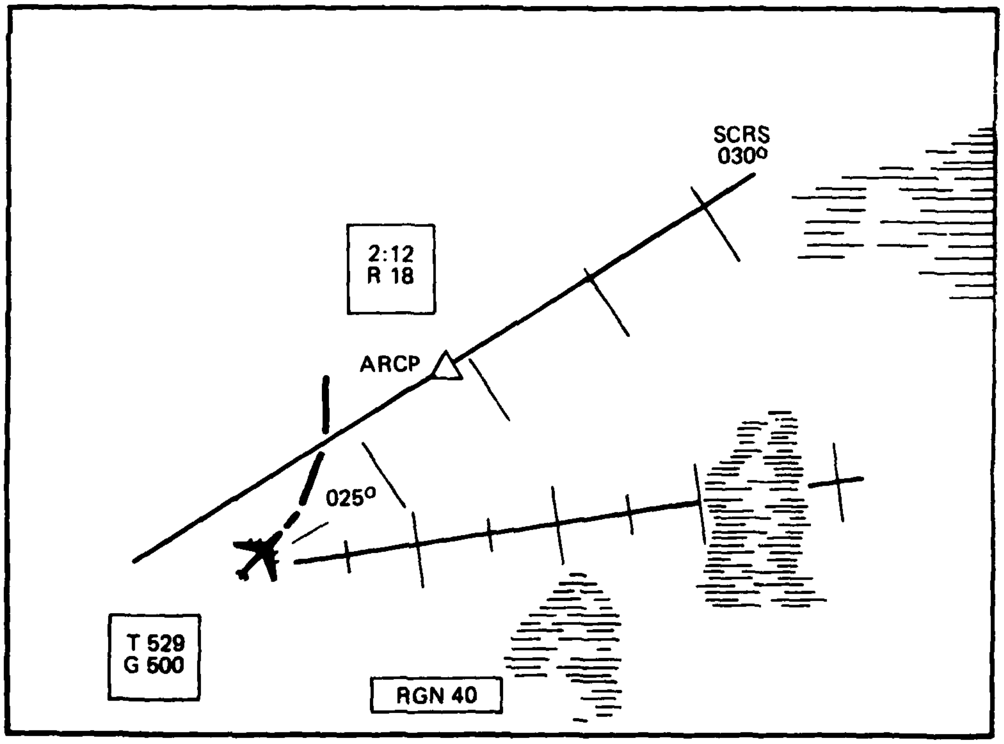
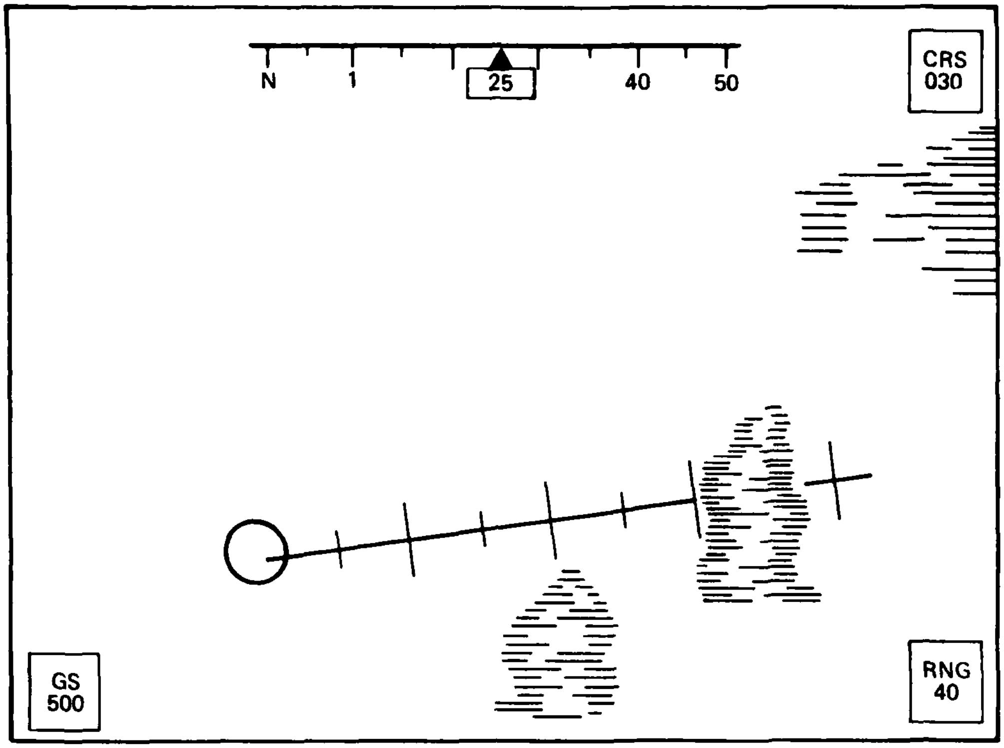


(after)

FIGURE 7. HSD MAP FORMAT W/WEATHER RADAR



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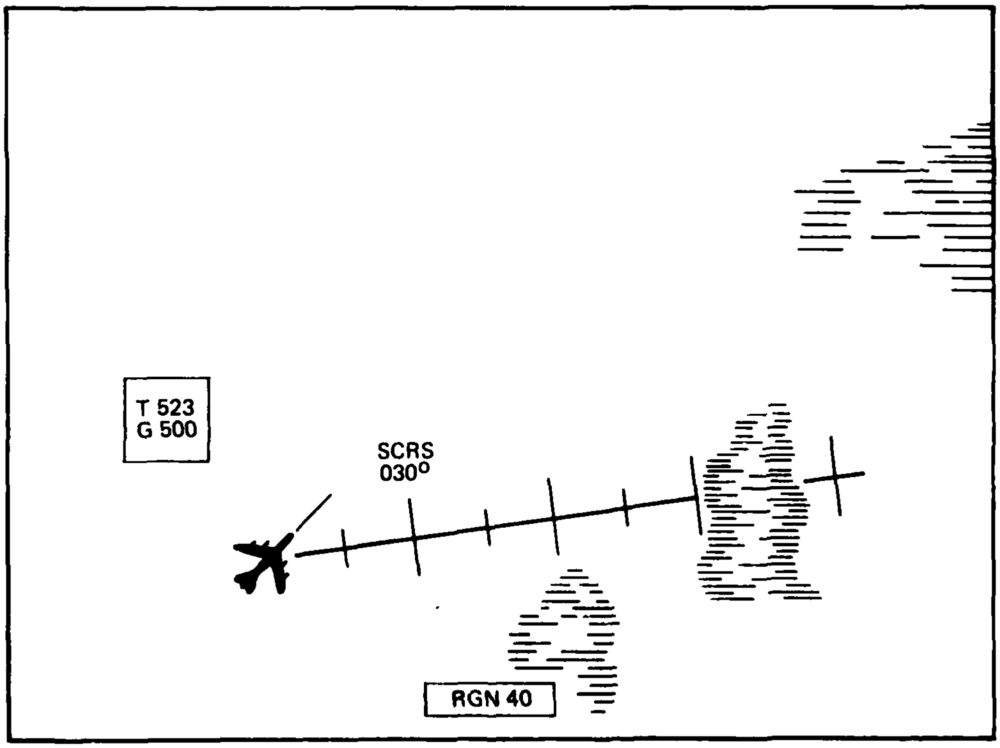
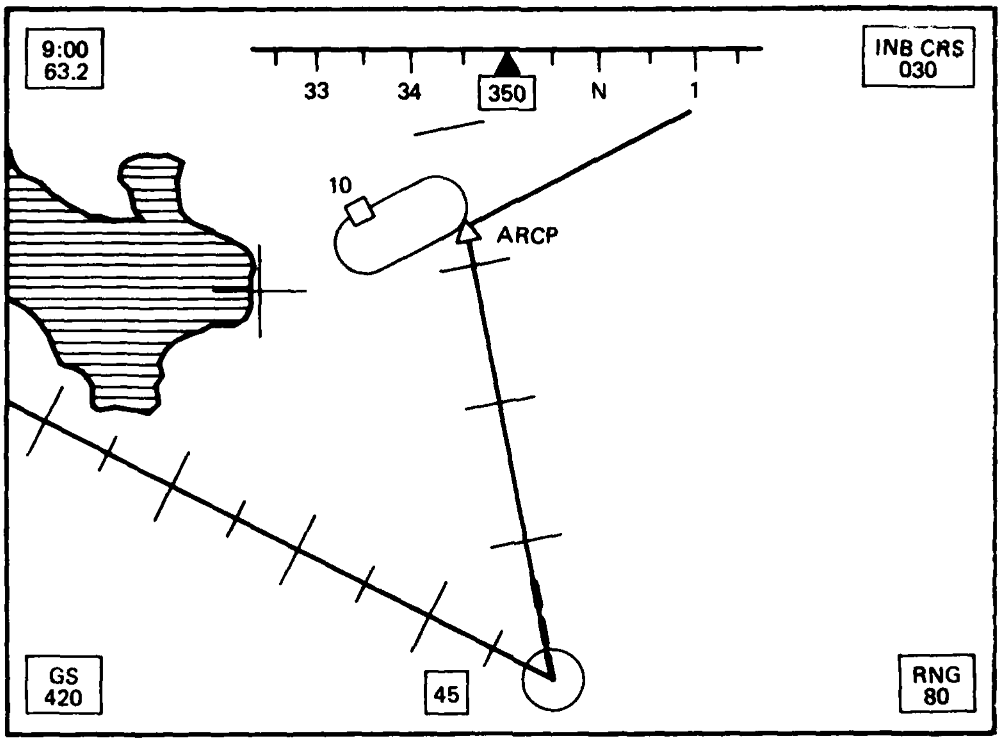


(after)

FIGURE 8. HSD FORMAT WEATHER RADAR



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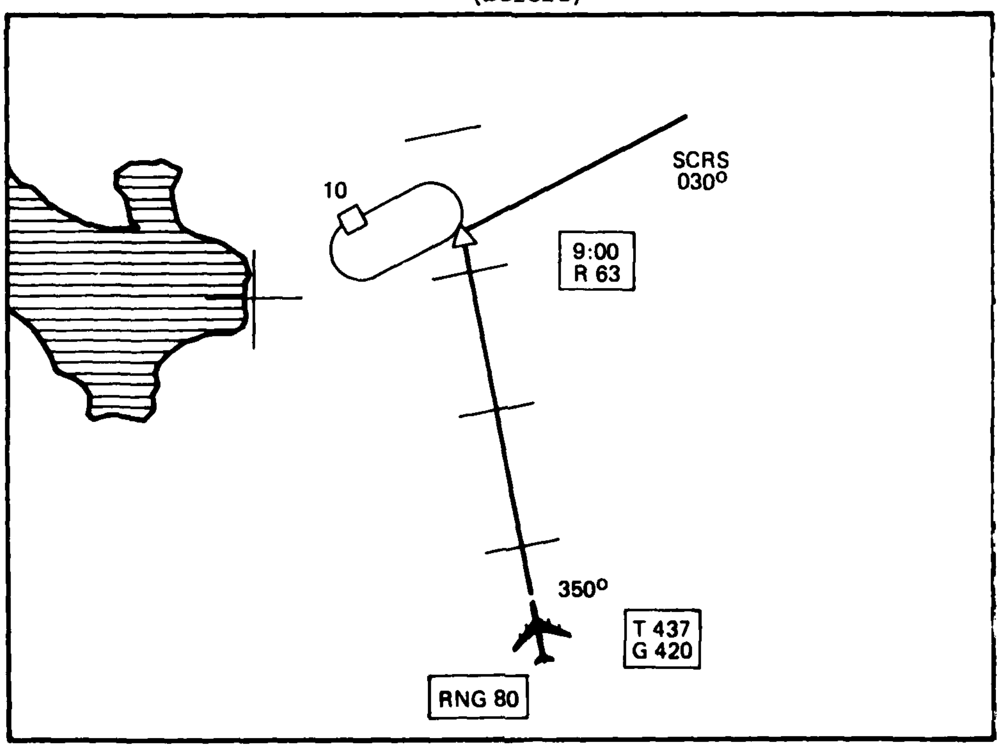
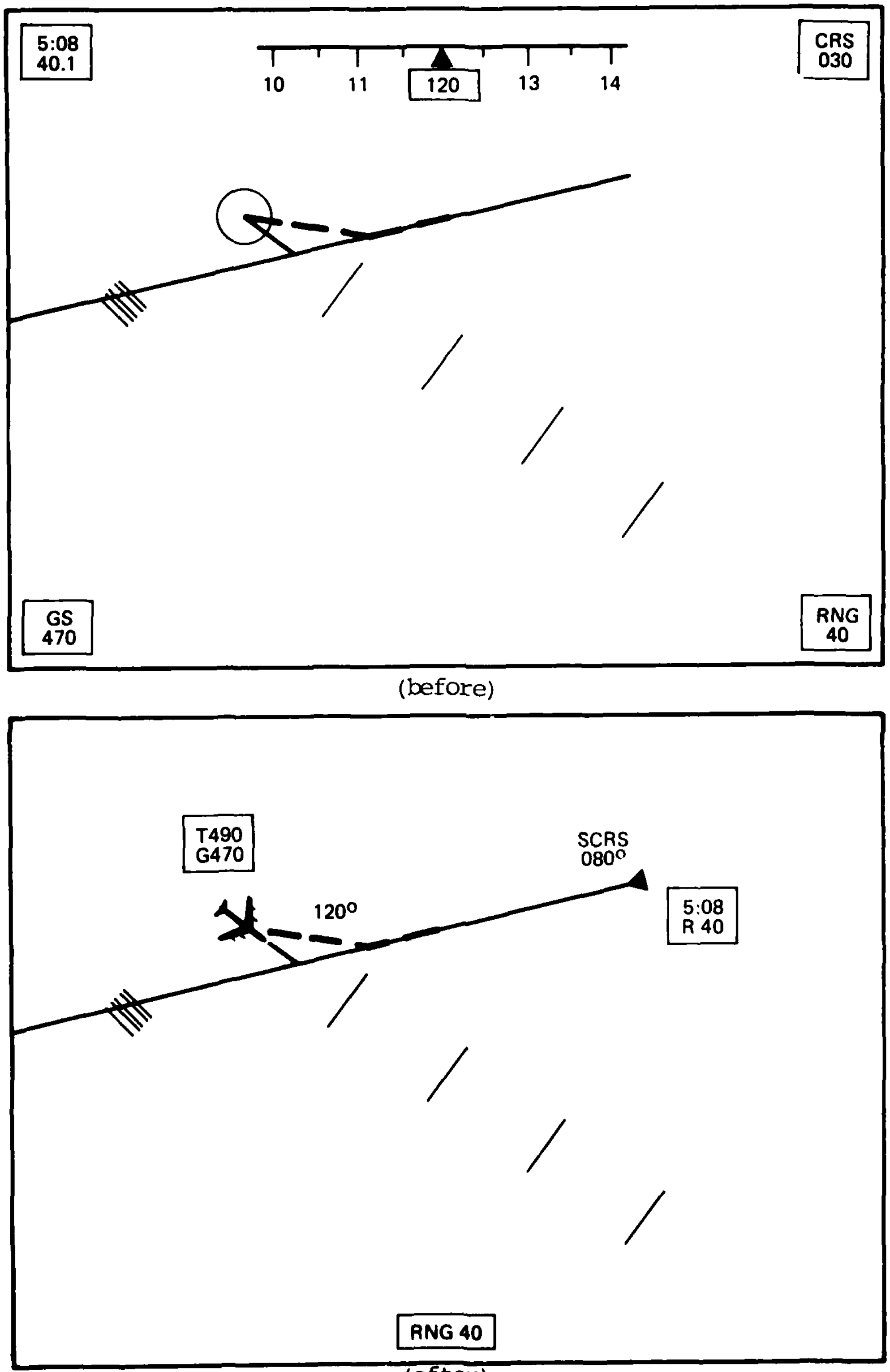


(after)

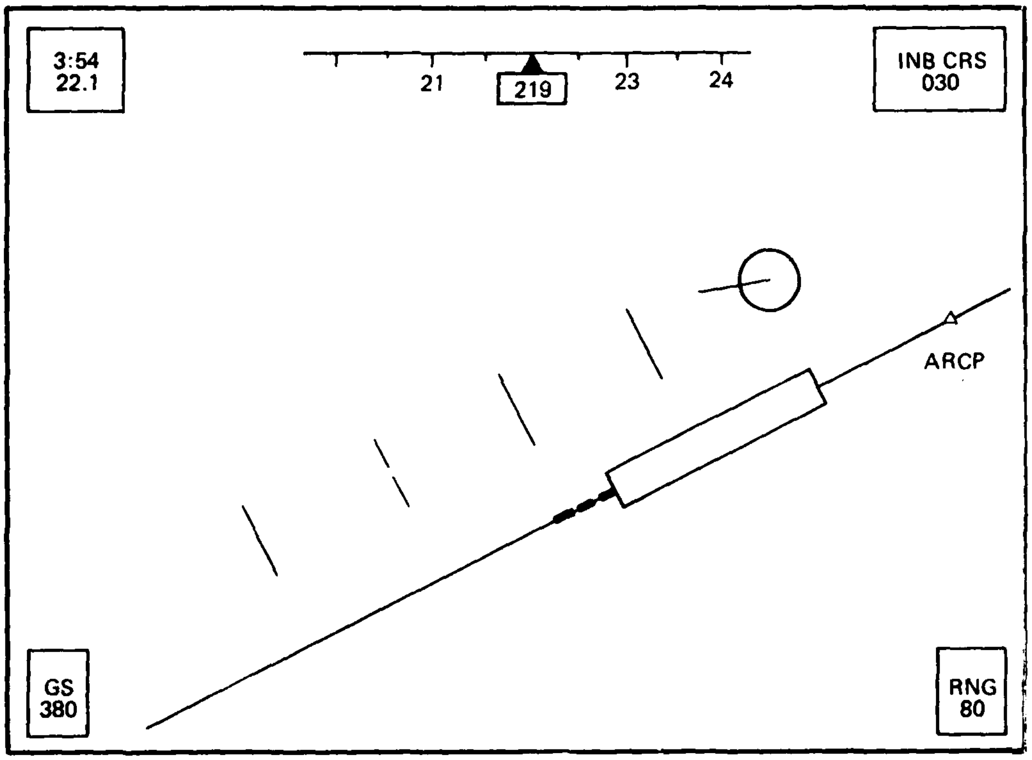
FIGURE 9. HOLD FORMAT W/RADAR



(before)

(after)

FIGURE 10. HSD MAP FORMAT



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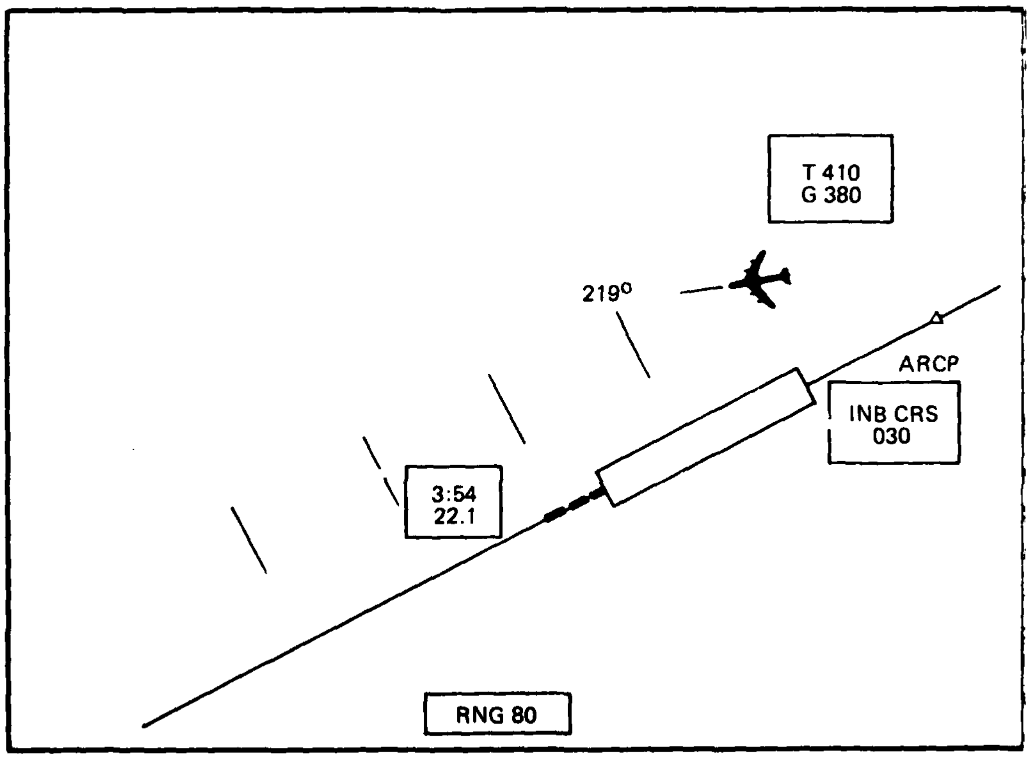


(after)

FIGURE 11. HSD RENDEZVOUS (RZ) FORMAT

TABLE 2. HSD TASKS

Task 6801 Applicable At Time 920P
Task 6806 Applicable At Time 834P, 910P, 912C, 915P

			TAACE		CODEM
06801		Check Map/Radar on HSD	12 77	000	10.39
680200	1	View Map/Radar Format	12.77	212	10.39
06906		Select/Check Map/Radar	14 94	000	12 56
680100	1	Select Map/Radar Mode	2.17	112	2.17
680200	1	View Map/Radar Format	12.77	212	10.39

Task 6802 Applicable At Time 832C
Task 6807 Applicable At Time 817P, 830C, 836P, 849P

06902		Check Weather Radar on HSD	12 77	000	10 39
680200	2	View Weather Radar Format	12.77	212	10.39
06807		Select/Check Weather Radar	14 94	000	12 56
680100	2	Select Weather Radar Mode	2.17	112	2.17
680200	2	View Weather Radar Format	12.77	212	10.39

Task 6803 Applicable At Time 826C, 847P
Task 6808 Applicable At Time 818P, 825C, 840P, 901P, 912P

06803		Check Hold/Radar on HSD	12 77	000	10 39
680200	3	View Hold/Radar Format	12.77	212	10.39
06808		Select/Check Hold/Radar	14 94	000	12 56
680100	3	Select Hold/Radar Mode	2.17	112	2.17
680200	3	View Hold/Radar Format	12.77	212	10.39

Task 6804 Applicable At Time 826P
Task 6809 Applicable At Time 825P

06804		Check Map on HSD	9 95	000	7 57
680200	4	View Map Format	9.95	212	7.57
06809		Select/Check Map	12 12	000	9 74
680100	4	Select Map Mode	2.17	112	2.17
680200	4	View Map Format	9.95	212	7.57

Task 6810 Applicable At Time 849C, 904P

06810		Select/Check Rendezvous	12 42	000	10 04
680100	5	Select Rendezvous Mode	2.17	112	2.17
680200	5	View Rendezvous Format	10.25	212	7.87

Note: P denotes Pilot Complexity Profile
C denotes Copilot Complexity Profile

These changes in the displays resulted in time savings in viewing the displays of 2.38 seconds for each of the formats so revised. The results of the changes are included in the CODEM design Ten and Sixty Second Complexity plots of Figures 3 and 4. The associated workload reductions in Task 1608 at 818 are reflected in the one second complexity plot shown in Figure 12. A review of the HSD formats used in segments of flight other than the refueling portion leads to the conclusion that the display can be simplified further. The information displayed on the HSI formats in particular is generally duplicated on the various map formats. Therefore, the deletion of the HSI formats should be considered.

RECOMMENDED CHANGES TO THE NAVIGATION MANAGEMENT CONTROL/DISPLAY UNIT

The NAV Management System used in the modernized KC-135 was a modern area navigation system. The system provided the capabilities to record and track (through its associated navigation management computer) data relevant to flight plan and flight status, present position, flight checklist, fuel management plan, and distance and bearing to navigation aids or waypoints. Further, the system determined the characteristics of the hold and rendezvous patterns. The navigation management computer also functioned as an Inertial Navigation System (INS). The control-display unit served as a data terminal, allowing the input of data into the system plus the display of tabular results on the CRT display panel (see Figure 13). Maps, waypoints, navigation aids, etc. were drawn on the HSD from the data derived or extrapolated from the navigation management system. The crew tasks associated with the operation of the navigation management system are tabulated in Table 3. The use of the navigation management system was limited during the refueling portion of the flight as can be seen from the table. Most of the loading was done during preflight, and fresh data was entered thereafter only if a specific change in the flight plan was desired. Such a need occurred at time 902 in the study mission when conditions required a previously unscheduled rendezvous. A review of this panel over a complete mission resulted in the following three suggested changes:

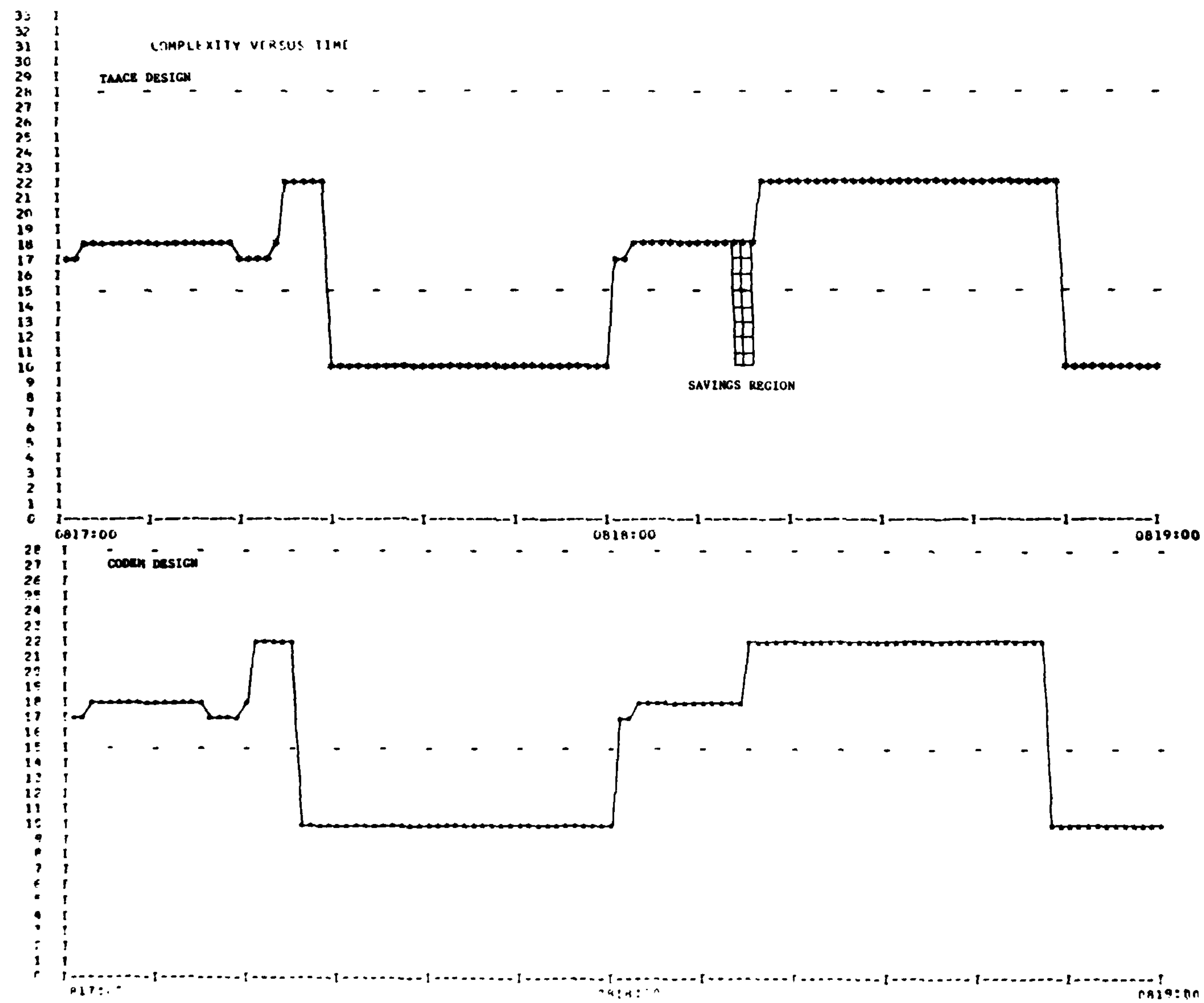


Figure 14. One Second Complexity Plot - HSD Savings

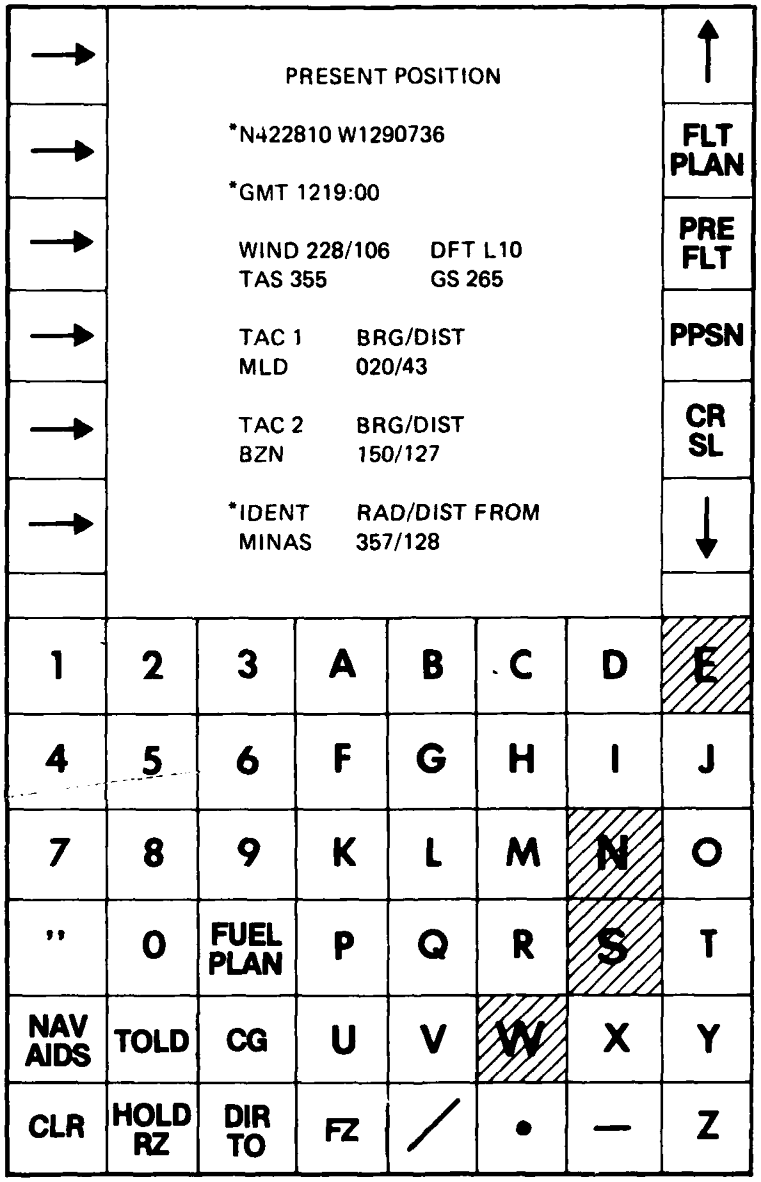


FIGURE 13. NAV MANAGEMENT CONTROL/DISPLAY UNIT

TABLE 3. NAV MANAGEMENT TASKS

Task 2601 Applicable At 825C

		TAACE		CODEM
02601	Updates INS	13 26	000	9 46
260300 1	Select 'PPSN' On NAV Mgmt	2.24	112	1.29
260300 2	Type in 'LAT' Info	4.39	212	3.44
260300 3	Type in 'LONG' Info	4.39	212	3.44
260300 4	Insert Data	2.24	112	1.29

Task 2602 Applicable At 831P

02602	Obtain ETA From INS	5 8	000	3 18
260300 11	Select 'FLT PLAN' On NAV Mgmt	2.24	112	1.29
260300 12	Select Waypoint Line	2.24	112	1.29
260300 13	Read ETA From Display	.60	212	.60

Task 2603 Applicable At 902C

02603	NAV Management Data Input	16 49	000	10 79
260300 5	Select 'HOLD/RZ' On NAV Mgmt	2.24	112	1.29
260300 6	Input Course 180/R	2.54	212	1.59
260300 7	Input Leg 100/R	2.54	212	1.59
260300 8	Input TAS/DFT CR	4.39	212	3.44
260300 9	Input Receiver IP	2.54	212	1.59
260300 10	Select 'PUSH TO INSERT"	2.24	112	1.29

Task 2605 Applicable At 926C

02605	Check NAV System	7 48	000	5 58
260300 14	Press "FLT PLAN' On NAV Mgmt	2.24	112	1.29
260500 1	View Display -- Nothing	1.50	212	1.50
260300 1	Select 'PPSN' On NAV Mgmt	2.24	112	1.29
260500 1	View Display -- Nothing	1.50	212	1.50

Note: P denotes Pilot Complexity Profile
C denotes Copilot Complexity Profile

1) The data input function during preflight as well as in-flight required a great deal of concentration on the part of the crew member involved. One suggested change was to use an external means of loading the flight data. For example, ground support loaders, cards, tape, disc, etc. could be loaded and brought onboard by the crew and inserted into a loading device. This would facilitate the preflight loading of the system and reduce the amount of preflight time required. The external data could be prepared on the ground, verified, then brought to the aircraft for insertion. This ground loading equipment would not help the inflight reprogramming which might be required. However, the number of unplanned rendezvous events should not be high during this type of mission.

2) The orientation of the push buttons should be revised.
   a) All control buttons should be relocated around the edge of the CRT so as to place them in a more coherent orientation with the display being changed.
   b) The numeric keys should be placed on the righthand side of the panel, with "N",'E", "W", and "S", incorporated in and appropriately highlighted on that portion of the keyboard. Those letters are always required with the numeric inputs for latitude and longitude.
   c) The alphabetic portion of the keyboard should be placed to the left of the panel. Some thought was given to rearrangement of the keys to a non-alphabetical order arrangement such as on a typewriter. However, the question of how alphabetic characters on a keyboard should be arranged is complex and would be deserving of a study in itself. Thus, the matter is mentioned here merely in the interest of identifying a potential workload problem. No solution is proposed.

d) The keyboard should be color coded so that alpha keys, numeric keys and control keys are represented by different colors. This change would facilitate the use of the keyboard.

3) The location of the control/display panel to the left of the copilot was awkward for data loading. The majority of flight crew personnel are righthand oriented and would either have to turn their bodies to load data into the panel with their more dexterous right hand, or load the data with their left hand which would be slower and less coordinated. One possible solution is to make the panel faceplate, including the display and push buttons, detachable. The unit would remain connected to the aircraft with an umbilical cord. The crew member involved could then hold the unit in his hand, like a hand-held calculator, in the manner he prefers.

These three changes, shown in Figure 14, were included in the analysis and are reflected in the CODEM design Ten and Sixty Second Complexity Plots of Figures 3 and 4. Figure 15 shows a one second complexity plot depicting the reduction in task time of Task 2603 at 902.

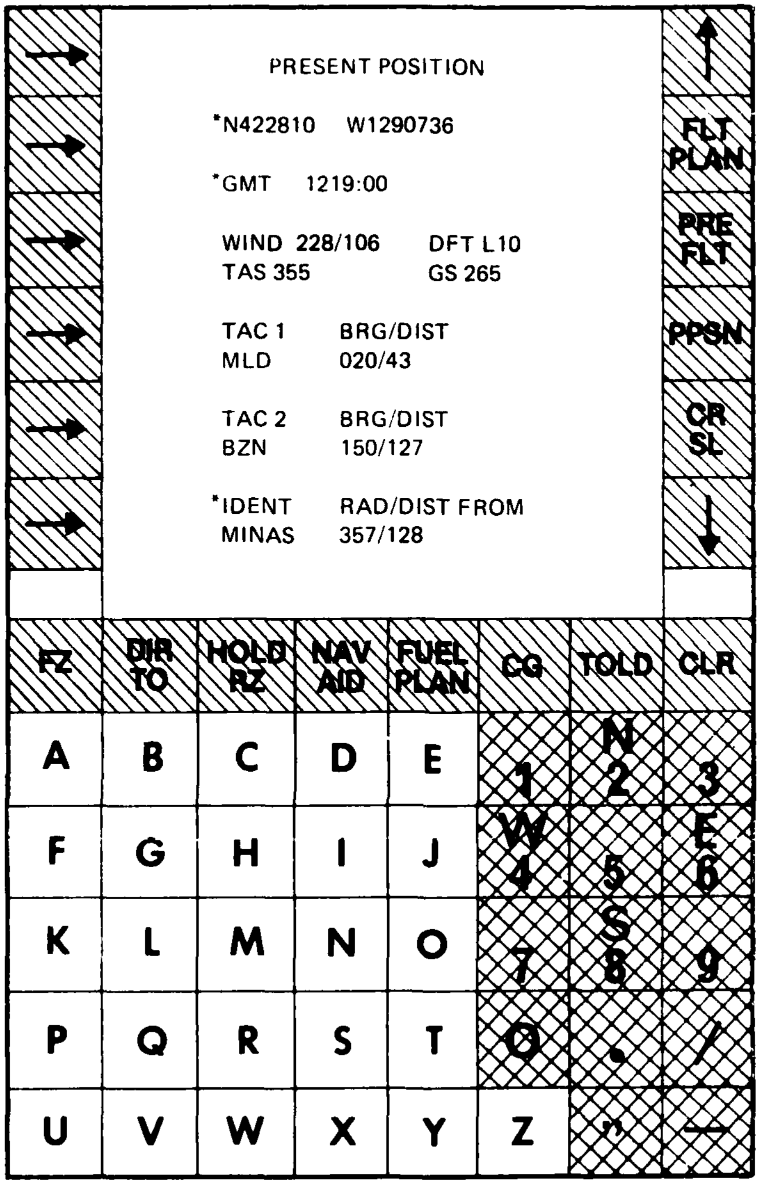


FIGURE 14. SUGGESTED NAV MANAGEMENT CONTROL/DISPLAY UNIT

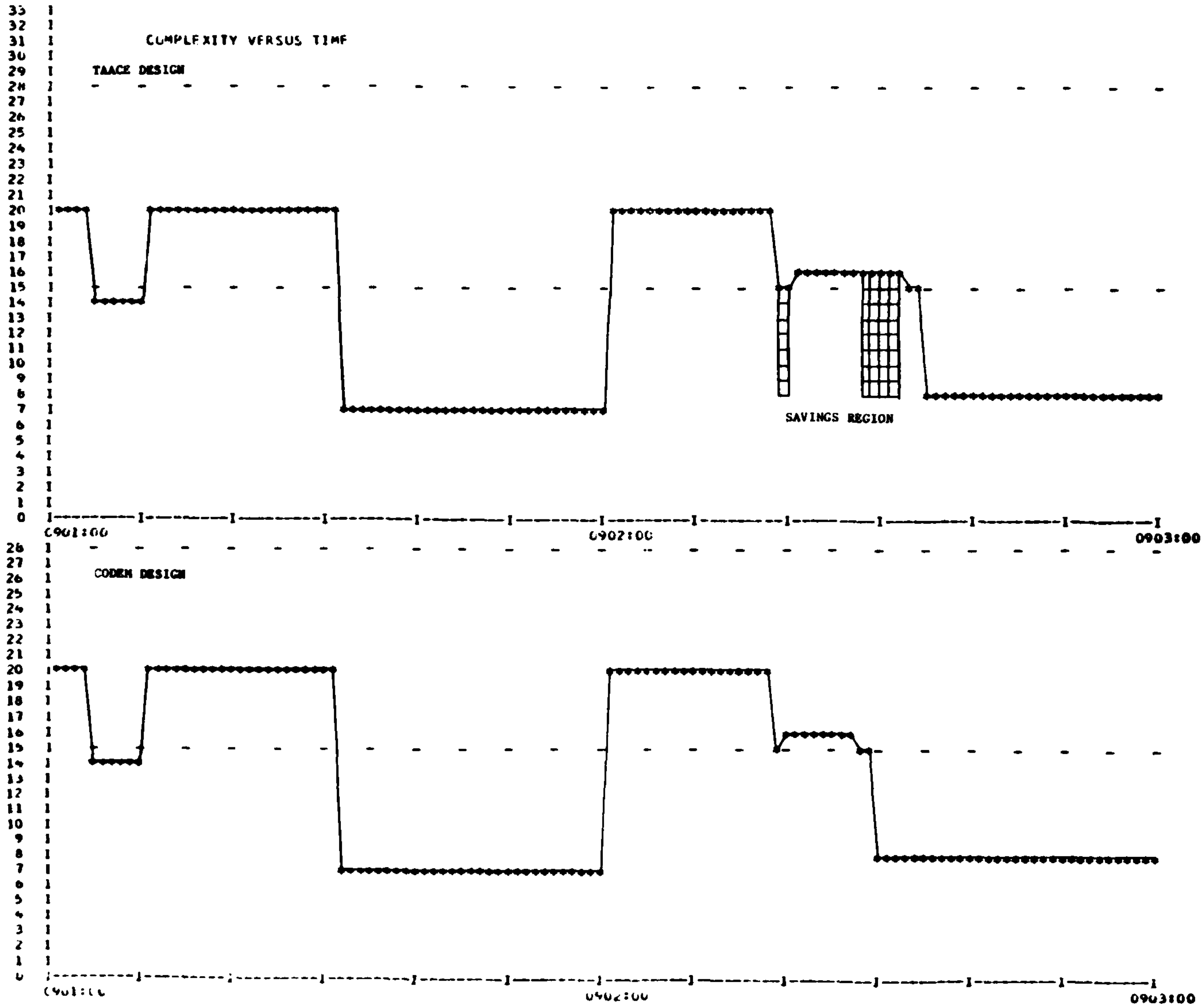


Figure 17. One Second Complexity Plot - Nav Mgmt Savings

SECTION IV
CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations which follow are arranged to address the two objectives of the study - the adequacy of the new controls and displays, and the preparation for a general validation of the CODEM.

Tanker Avionics Controls and Displays

The controls and displays, as redesigned for the modernized KC-135 tanker, are satisfactory for the Rendezvous and In-Flight Refueling segment of the mission. The modernized KC-135 - as a result of automating the navigation system, combining the HSD presentations, improving the operation of the fuel panel, and incorporating other changes to and relocations of equipment in the cockpit - can be operated effectively during the Rendezvous and In-Flight Refueling portion of the mission by only a pilot and copilot.

The CODEM design Ten and Sixty Second Complexity plots shown in Figures 3 to 6 show that the only exceedances of the Design Goal predicted for the mission segment which was analyzed are due to the high volume of radio communications involved. These periods of exceedance are usually brief in nature due to the abbreviated nature of aircraft communications. Further, in a particularly tight situation where such a communications level could not be supported, the crew could request a hold until things loosened up. Accordingly, no significant crew workload problems are anticipated for the improved system.

The CODEM generated complexity plots also show that, as expected, the pilot is generally busier than the copilot. The pilot's higher workload results from his constant involvement in flying the aircraft. The pilot's unique additional tasks in the Rendezvous and In-Flight Refueling phase of the mission are sufficiently distributed that in no instance was he found to be functioning in an overloaded state.

Although no equipment changes were dictated by the predicted crew work-loads, the need for minor modifications to the new hardware elements was indicated. These modifications will improve the operability of the equipments and might prove to be important if the units are ever used in a more critical operational environment. The complexity profiles for the modified flight deck equipment elements confirm that the crew workloads related to their operation would be less. The assessment of the associated cost and schedule implications of the suggested changes would establish the feasibility of implementing the suggested changes. Such an assessment was beyond the scope of this study.

CODEM

The study results indicated that the CODEM predictions were consistent with the general observations recorded during the simulator runs at Wright-Patterson Air Force Base as well as those made subsequently during a training flight onboard a KC-135 aircraft out of arch Air Force Base. The CODEM application in this study demonstrates that the model is sensitive to aircraft control and display design. In all cases, perturbations in the complexity plots were easily traceable to the particular hardware feature involved. Further, in reviewing the study data, there is no doubt that the model sensibly reflects workload differences. Therefore, the development of the model should be completed as soon as possible. The continuing development of the CODEM will involve two major tasks. Fortunately, these tasks can be performed in parallel if circumstances should indicate the desirability of that approach.

First, the model must be validated experimentally to specific crew performance measurements. Such experimental validation should be carried out on a high fidelity aircraft simulator. The adjustments to the CODEM resulting from the experimental validation will not improve the model's consistency. The CODEM is quantitative and it is computerized, and the results from its application are presently consistent. However, the validation should result in greater sensitivity in the model. Simply stated, if the CODEM's Task Complexity Classification Matrix is adjusted to conform to the experimental data, the model should provide more precise (and therefore more sensitive) predictions of crew performance.

The program which will be required to validate the CODEM experimentally will require government support. Certainly, the CODEM is very useful in its present "unvalidated" state. However, it is believed that the widespread acceptance and utilization of the model cannot be expected until it is fully validated. The early experimental validation of the CODEM is therefore urged, and the support of the validation by the Air Force is strongly recommended.

The second task related to the CODEM's development is concerned with the refinement of the model's computer program. The CODEM computer program is still in a developmental state and therefore somewhat cumbersome to use. Additional effort will be required to increase its general utility as well as the efficiency of its algorithms. This work is now in progress as part of the Northrop Independent Research and Development (IR&D) program and is expected to continue through the coming year. It is believed that a substantially improved version of the CODEM could be ready for experimental validation by the time such a validation program could be implemented.

In the meantime, Northrop greatly appreciates the opportunity which has been afforded by this study to validate the CODEM generally. The accompanying workload predictions should facilitate this general validation. The enthusiastic support and cooperation of the AFWAL/FIGR personnel supporting this study have been outstanding, and their contribution to its success is gratefully acknowledged.

REFERENCES

(1) AFWAL-TR-80-3030, "Tanker Avionics/Aircrew Complement Evaluation (TAACE) Phase Ø - Analysis and Mockup" Volume III, Mission Scenario

(2) AFWAL-TR-80-3030, "Tanker Avionics/Aircrew Complement Evaluation (TAACE) Phase Ø - Analysis and Mockup" Volume I, Results

(3) Bunker Ramo Report, No. 4506-020-5100-9, "Tanker Avionics/Aircrew Complement Evaluation (TAACE) Mockup Evaluation Phase Volume 3, dated June 1979

(4) "An Index of Electronic Equipment Operability - Datastore", Report No. AIR-C43-1/62-RP(1), Prepared by the Signal Corps

(5) Siegel, A.J. and Wolf, J.J., "Techniques for Evaluating Operator Loading in Man-Machine Systems - A Description of a Model and the Results of its First Application", Applied Psychological Services, Wayne, Pennsylvania, Feb. 1959

APPENDIX A

THE CONTROLS AND DISPLAY EVALUATION MODEL
(CODEM)

APPENDIX A

THE CONTROLS AND DISPLAY EVALUATION MODEL (CODEM)

The overall design of aircraft crew stations, because of the many disciplines involved, has remained primarily a qualitative endeavor. True, each of the many crew station controls and displays has evolved under specific, and often ingenious, engineering treatment. Unfortunately, this technical evolution of the elements has not been accompanied by similar progress at the aggregate level. A reliable crew station integration method, which would serve to constrain the design of the elements as well as to ensure the integrity of the crew station as a whole, simply has not been available. This paradoxical situation has become even more pronounced in recent years with the accelerating advances being realized in the avionics technologies. The need for an improved controls and displays integration methodology has become correspondingly more urgent.

The primary purpose of the desired integration method would be to serve as a practical, analytic, controls and displays design tool. Accordingly, it was reasoned that the method should be quantitative, simple, economical, easy to use, fast, reliable, and realistically sensitive to the principal design features of the controls and displays.

It was decided that a simple, "limit design" approach would best serve the needs of the method. Such an approach, which establishes absolute design limits and progressively tests the emerging design deterministically for conformance to the limits, is used commonly in aircraft design. A limit design model would be simple, economical, easy to use and fast. But what about the metric for such a model to assure that the method will be quantitative, reliable and sensitive?

After considerable deliberation it was concluded that crew performance should be the metric, provided of course some means could be devised to relate quantitatively crew performance to the design of the equipment elements. The design integration function could then be performed straightforwardly. Specifically, the physical and functional features of the controls and displays could be altered to produce predicted levels of crew performance, and the process could be repeated until the desired or best practicable level of crew performance was realized.

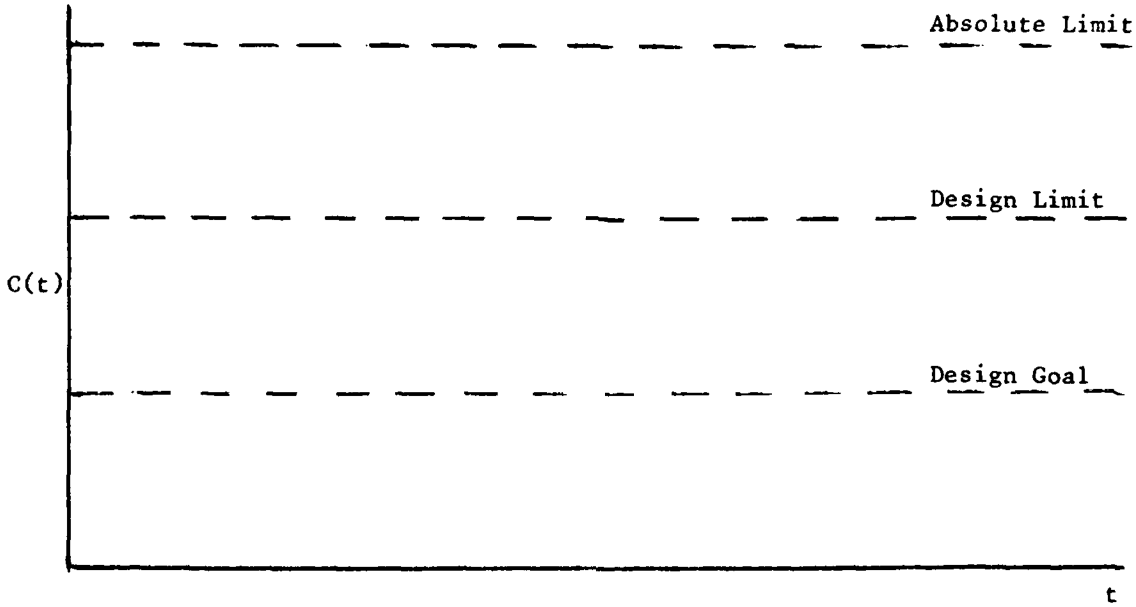
The matter of quantitatively relating crew performance to the controls and displays equipment elements was then addressed. First, the area of human performance was reviewed to establish just what was known about the subject that could be used as the basis for quantification. It was determined that human operator performance could be expressed as a function of task complexity, and that task complexity, in turn, could be related quantitatively to specific features of the controls and displays. From these established relationships, a numerical task complexity classification matrix was developed and design criteria in terms of task complexity levels were defined.

The task complexity classification matrix permits each elementary task within any crew function to be classified according to its difficulty, time criticality, and necessity. On the basis of that classification, the task is given a complexity index which denotes its complexity - the larger the index, the greater the complexity. The task is also given a time interval which corresponds to the time required for the performance of the task. The task time interval is assigned in exactly the same manner as such assignments are now made in the course of performing the traditional unidimensional, time-line analyses. The task-specific complexity indices and time intervals permit the crew tasks to be expressed as a plot of complexity versus time. Thus a complexity profile of any crew function or collection of functions, can be generated for the particular controls and displays involved.

Three design criteria have been defined in terms of the corresponding task complexity levels - "design goal", "design limit", and "absolute limit". The "design goal" is specified as the level of maximum single task complexity. That is, the maximum complexity level involved when all elementary tasks can be performed serially and human performance is relatively linear. The "design limit" is defined as the maximum complexity level at which multiple tasks should be performed simultaneously. In other words, the design limit is the highest level of comfortable task time sharing and is the level at which human performance is relatively linear if the time interval involved is limited. The "absolute limit" is that level of task complexity at which adequate human response is not possible.

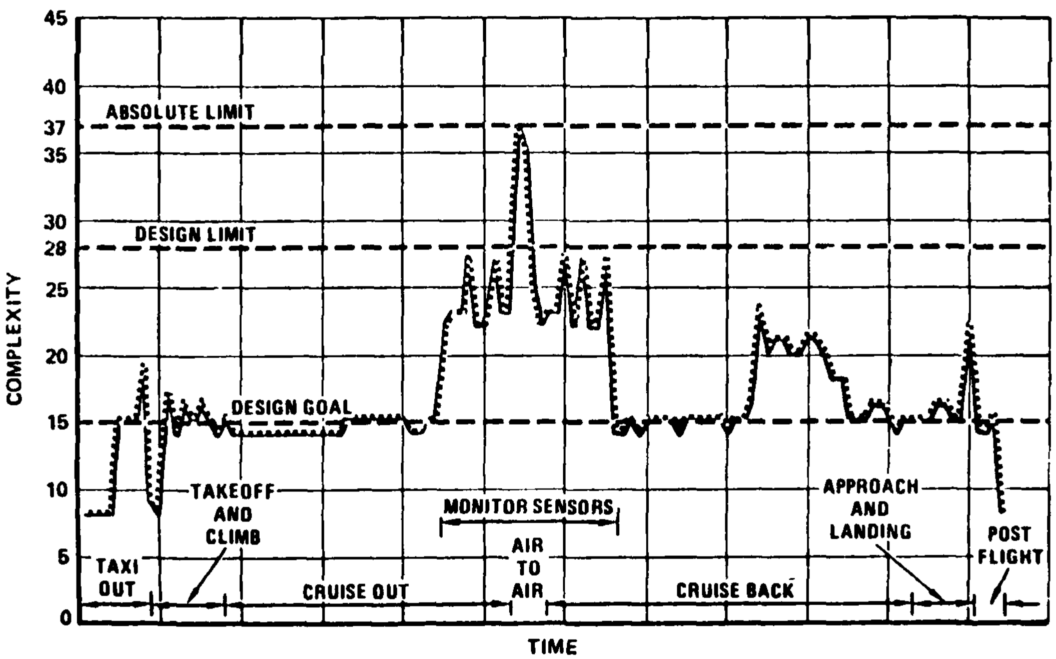
By virtue of the "limit design" approach which was invoked at the outset, the complexity criteria in all cases are based on human performance characteristics representative of the slowest members of the crew population involved. The task time intervals are similarly conservative. Ideally then, the crew station engineer would strive to design the controls and displays so as to keep the complexity peaks as close to the design goal as practicable. For those complexity peaks at or near the design limit, he would assure that the associated time intervals were limited to, say, thirty seconds. In no case would he allow the complexity peaks to exceed the design limit. Thus the complexity band between the design and absolute limits would constitute the margin of safety of the design. Figure A-1(a) shows the charted design criteria. Figure A-1(b) shows a typical, greatly compressed, tactical aircraft complexity profile as it would appear when referenced to the design criteria.

This limit design approach to controls and displays is quite analogous to that used for many years in aircraft structures. In the design of simple sheet-stringer panels, for example, the parts were configured on the basis of analysis to keep the material involved well within its elastic or linear response region, with a suitable safety margin. With the CODEM, the parts (controls and displays) are configured on the basis of analysis to keep the human operator well within his linear response region - again, with a suitable safety margin. But the analogy does not end there. Just as the structural engineer found it necessary, despite his analysis, to subject test specimens to static tests to verify the adequacy of his design, the



(a)

CHART OF TASK COMPLEXITY DESIGN CRITERIA



(b)

Figure A-1. Compressed Task Complexity Profile of a Typical Tactical Aircraft

crew station engineer, even with the CODEM, must turn to man-in-the-loop simulation tests to verify the results of his efforts.

In the structures case, the analytic model involved was not so precise as to obviate the need for empirical verification. Yet the structural engineer never would have attempted to design a part without using the model. While a more precise (and complex) structural analysis model would have given more accurate predictions, these predictions alone would not have been sufficient to by-pass the usual empirical verification, and static tests would still be necessary. Hence, the additional time and expense involved in using a more accurate structural design model could not be justified. This is similar to the situation which prevails in crew station engineering today.

It appears that, over the years, the crew station area has suffered from a widespread reluctance to resort to simple analytic models, particularly limit design models. The reason usually given for not using a simple, human performance, analytic model - namely, the extreme variability of man (even within himself) - is the very reason why such a model should have been used. The impracticability of defining human performance precisely suggests strongly that a simple model based on good approximations (assuming a satisfactory formulation of such could be devised) would suffice and, indeed, would afford a much more cost effective method of achieving the desired end - better man-machine interface design.

The foregoing discussions describe the technical and philosophical origins of the CODEM. But the real value of the model lies in its simplicity and effectiveness. It was determined early in the developmental process that the method was capable of predicting crew performance as a function of the controls and displays equipment involved. Hence only two additional features were needed to complete its development as a practical design tool - the time constraints on the crew tasks due to the mission and the aircraft involved, and the computerizing of the model. The model was programmed in FORTRAN. Its computer program included provisions for timing each mission segment for the particular aircraft involved in the analysis, as well as provisions for producing time-correlated, equipment-coded, task printouts to accompany the computer generated complexity profiles. The

CODEM model was also programmed to require that all tasks related to a particular mission segment had to be performed within that segment. In other words, tasks could not spill over from one segment to the next, regardless of the time limitations involved.

The way the model works can best be described by simple example. Assume that the takeoff segment of a mission is to be analyzed and, further, assume that (for the sake of the example only) all takeoffs are identical in terms of the equipment and the tasks involved. The analysis would proceed by first detailing all of the tasks involved in takeoff and then generating a complexity profile for the takeoff. If no aircraft timing constraints were involved, the complexity profile might be as shown in Figure A-2(a). Now, assume that the takeoff is being made in a slow trainer aircraft such that the time available for takeoff exceeds the time required to perform the tasks as they were originally sequenced. The repetitive tasks would continue to be performed over the extended period. However, the non-repetitive tasks would be redistributed over the longer takeoff period and, although the complexity of each such task would not diminish in this redistribution, the tasks would then separate from one another sufficiently that the effect would be the same as a reduction in complexity. Essentially, the net effect would be the same as if the area under the complexity curve had spread itself out evenly over the longer takeoff period, thus reducing the complexity proportionately as shown in Figure A-2(b). Next, assume that the takeoff is being made in a high performance aircraft in afterburner. In this case, the time available for takeoff is less than that required in the original sequence and the area under the complexity curve is squeezed into that shorter time inverval. The complexity level then increases proportionately as shown in Figure A-2(c).

At this point, let us discuss briefly how the CODEM is used. Following the detailed mission, aircraft and equipment-related task analyses, the data are coded and loaded into the CODEM.

The CODEM computer program contains five data files. These data files are accessed to put together the appropriate mission files which are used in the complexity plotting portion of the computer program. The five files are: the BLOCK FILE, the TASK FILE, the ELEMENT FILE, the TASK ASSEMBLY FILE, and the ELEMENT ASSEMBLY FILE.

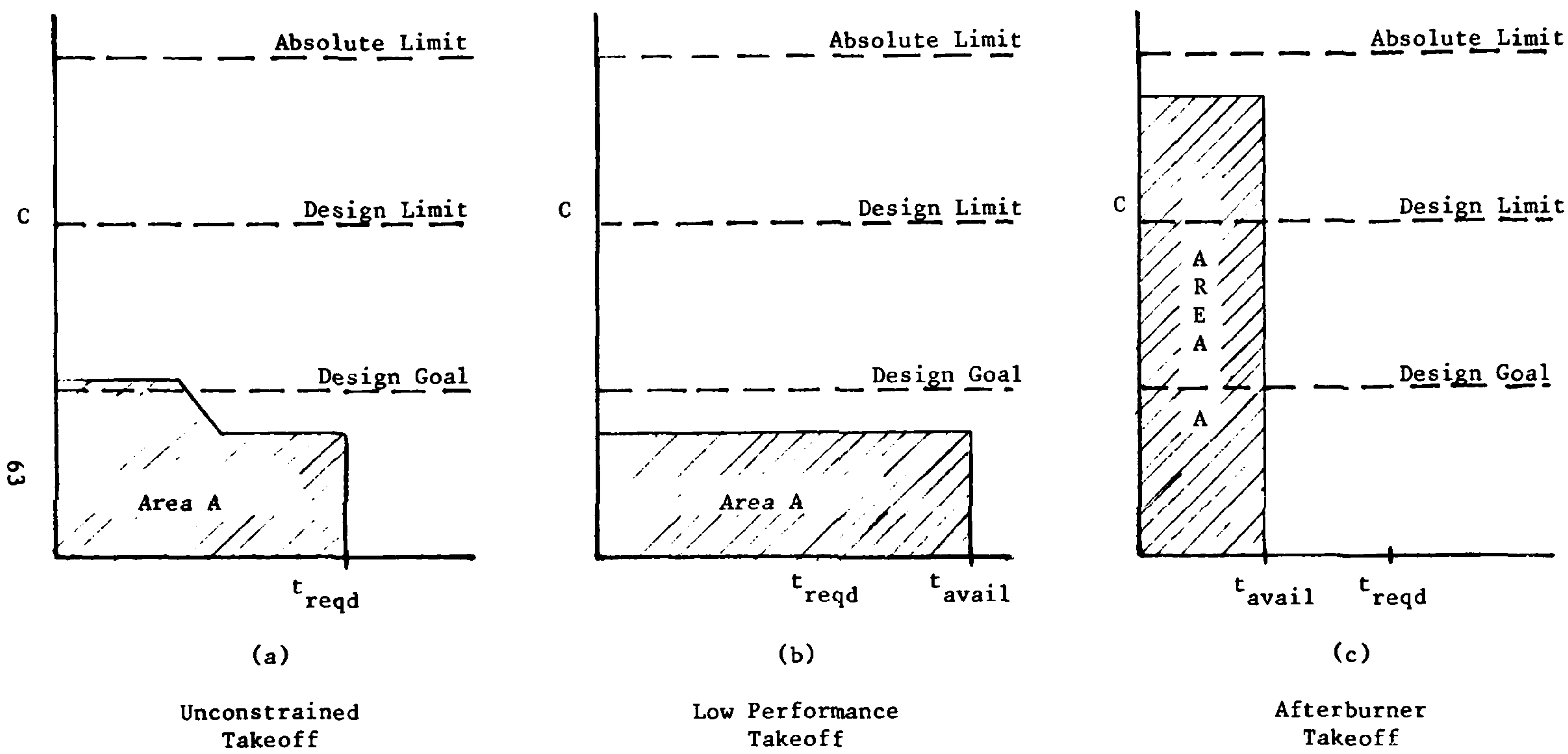


Figure A-2. Simplified Example of a CODEM Takeoff Analysis

The BLOCK FILE contains the assigned block numbers and the major titles of each of the tasks involved in the block. The file breaks down the mission segment into one minute blocks. The blocks are identified following each of the one second complexity plots.

The TASK FILE contains the assigned task numbers and the assigned task titles and are similarly identified after the block data on the one second complexity plots.

The ELEMENT FILE contains each assigned element of the task with its associated element number, element name, and its assigned time and complexity.

The TASK ASSEMBLY FILE contains a tabulation of all tasks, by assigned numbers, that are applicable to the blocks.

The ELEMENT ASSEMBLY FILE contains a tabulation by number of all elements that are assigned to each task.

These five files are loaded with all the data that are necessary to generate the MISSION FILE. The MISSION FILE is the input to the task complexity profile generation portion of the CODEM computer program.

The CODEM computer program consists of two subprograms, one called MIXUP and one called TASK2.

The MIXUP program assembles the required mission profiles from the five data files (i.e., the BLOCK FILE, the TASK FILE, the ELEMENT FILE, the TASK ASSEMBLY FILE, and the ELEMENT ASSEMBLY FILE) by sequentially reviewing the blocks, extracting the appropriate tasks per block using the TASK ASSEMBLY FILES, then extracting the element applicable to each task using the ELEMENT ASSEMBLY FILE and assembling them in place. The resultant mission file is stored for passing to the TASK2 program.

The TASK2 program takes the mission file and generates plots of the peak complexities occurring within time intervals of one second, ten seconds and sixty seconds. The ten second and sixty second plots are provided to facilitate the design process by making it easy for the designer to identify rapidly those time segments in which high complexities exist. The one second plot is used in the course of the consequent analyses.

The CODEM is operated to produce plots of the associated task complexities, along with a printout of the indiviudal tasks, for each crew member.

The equipment features responsible for any of the unacceptably high complexity peaks noted on the resultant complexity profiles can be identified readily by examining the task printouts. Three actions can be taken to reduce any unacceptable complexity peak - redesign of the equipment causing the peak, replacement of that equipment with another unit of like function, or elimination of the offending equipment functions altogether by automation. Each alternative solution will yield a unique complexity signature when the corresponding data are entered into the CODEM. Since the designer is dealing with real hardware and software, he can also assess the cost and schedule implications of each alternative as well. The simultaneous availability of such crew performance (i.e., complexity), cost and schedule information allows the designer to identify quickly the most appropriate alternative for the prevailing circumstances. Even in those instances where program cost and schedule limitations preclude the implementation of an indicated cockpit equipment change, the model is still useful in that the particular deficiency involved is identified. Special training programs can then be instituted to avert the predicted problem.

The CODEM task complexity indices were validated to a limited extent during the initial phase of the development of the concept. Specifically, a number of actual aircraft carrier landing tasks, which were found to be subject to failure in an earlier Siegel and Wolf study (5), were used in an analytical correlation test of the complexity indices. The tasks were given complexity ratings in accordance with CODEM and the complexity ratings were correlated to the respective number of task failures recorded by Siegel and Wolf in their study. Figure A-3 shows the results of the correlation test in terms of two plots adjusted for best fit. The close correspondence of the CODEM predictions to the Siegel and Wolf data indicated that the concept was valid. Work then continued to complete the model.

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(5) Siegel, A.J. and Wolf, J.J., "Techniques for Evaluating Operator Loading in Man-Machine Systems - A Description of a Model and the Results of Its First Application", Applied Psychological Services, Wayne, Pennsylvania, Feb. 1959.

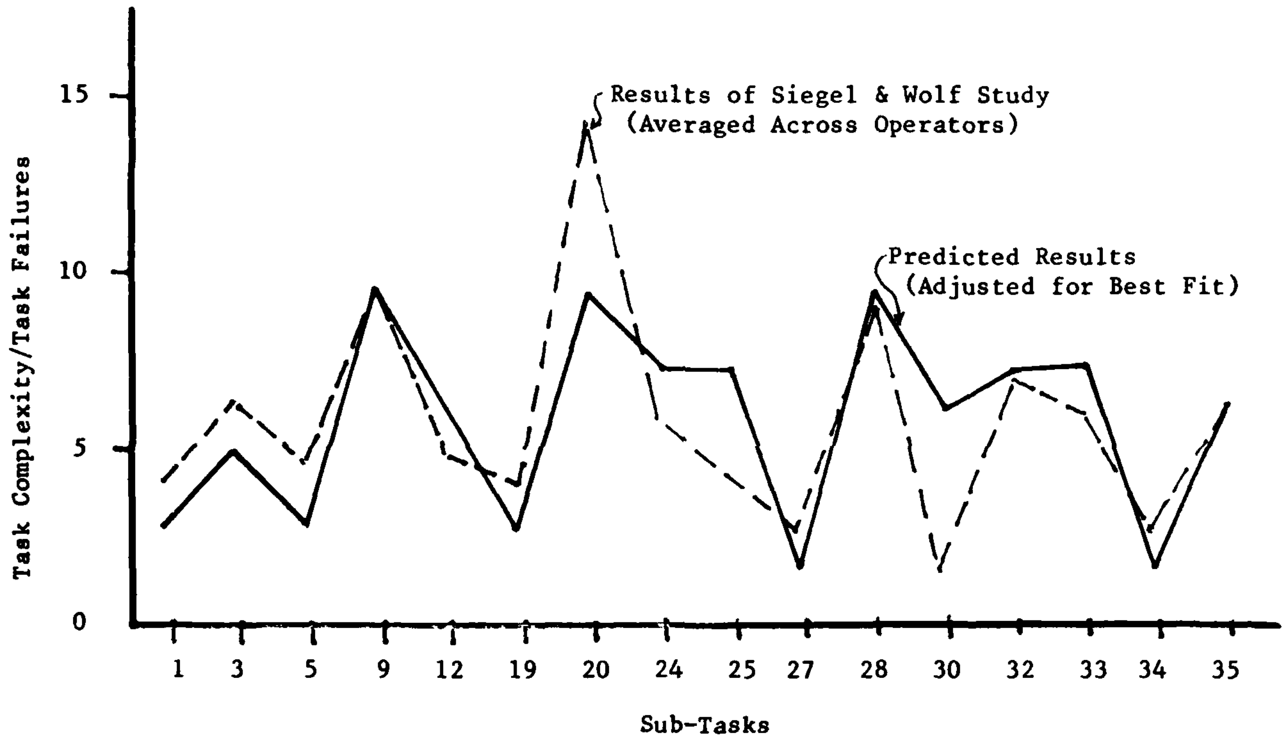

Figure A-3. Comparison of CODEM Predictions and Empirical Data from Siegel and Wolf

The TAACE application of the CODEM will serve to further validate the model. However, it should be recognized that the TAACE application results will constitute only a first-order validation of the CODEM due to the coarse and general nature of the data correlation involved (e.g., the results of the TAACE simulations can be compared with the CODEM predictions only in a general manner). Although the TAACE application will verify the sensibility, consistency and sensitivity of the model, considerably more experimental rigor will be necessary for the complete validation of the CODEM. The required experimentation would involve precisely controlled man-in-loop simulations in which crew performance measurements are made in the interest of adjusting the values within the Task Complexity Classification Matrix of the CODEM to conform to the experimental results. It is believed that industry-wide acceptance and utilization of the CODEM will be contingent upon this final validation.

APPENDIX B

APPROVED TASK DESCRIPTIONS

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0815 REVIEW CREW PROCEDURES	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION DISCUSSES PROCEDURE WITH CREW PILOT -"OUR TURN INTO THE ANCHOR TRACK WILL BE MADE PRIOR TO THE ANCHOR POINT ON THE DOWNWIND SIDE. CONTACT GCI AND TACO33."	
0816 PREP FOR CONTACT CHECKLIST	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION INITIATES CHECKLIST PILOT CHECKS ALTIMETER PILOT CHECKS STABILIZER TRIM PILOT CHECKS AUTOPILOT STABILIZER TRIM	RESPONDS TO BRIEFING CP -"ROGER." READS CHECKLIST 1. ALTIMETERS - SET 29,92 COPILOT CHECKS ALTIMETER 2. RADAR RZ BEACON - OPERATE COPILOT TURNS ON BEACON 3. STABILIZER TRIM 4. AUTOPILOT STABILIZER TRIM FOLLOWUP

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0817 CONTINUES CHECKLIST	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION MONITORS WEATHER RADAR CHECKS OXYGEN	5. TACAN - SET A/A, TURN ON A/A TACAN 6. STROBE LIGHTS ON, TURN ON STROBE LIGHTS 7. OXYGEN - CHECKS OXYGEN 8. DUMP FUEL - VERIFY OPERABLE COMMUNICATES WITH GCI CP-"BLACKBALL, FILIP 66, OUR TURN WILL BE INTO THE DOWNWIND SIDE OF ANCHOR" GCI-"COPY 66" COMMUNICATES WITH TACO33 TACO 33-"FILIP 66 TACO33 ON FREQUENCY" CP-"ROGER 33"
0818 CONTINUES CHECKLIST	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION SELECTS HOLD/RDR DISPLAY ON HSD MONITORS ANCHOR INFORMATION	9. RADIO CONTACT - ESTABLISH CP - "BLACKBALL, FILIP 66, REQUESTING AIR REFUELING INFORMATION" GCI - "ROGER 66, HERE IS REQUESTED INFORMATION ALTIMETER SETTING 2992 OFFLOAD AS REQUIRED REFUELING HEADING 039/222 WEATHER A/R AREA SOME BUILDUPS STATE YOUR PRESENT POSITION" CP - "FILIP 66 IS ON THE 316° AT 20 DME FROM CHANNEL 77" GCI - "COPY 66, AUTHENTICATE GOLF-ALPHA-SIERRA" CP - "ROGER BLACKBALL, FILIP 66 ALPHA-ALPHA"

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0819 CONTINUES CHECKLIST	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	10. SEARCH RADAR FUNCTION SWITCH - BEACON COPILOT TURNS ON SEARCH RADAR 11. UHF - DF COPILOT TURNS ON UHF - DF ON COMM 1 12. POSITION LIGHTS COPILOT SETS POSITION LIGHTS 13. RENDEZVOUS BEACON LIGHT COPILOT TURNS ON UPPER RENDEZVOUS LIGHT 14. STROBE LIGHTS COPILOT TURNS OFF STROBE LIGHT 15. FUEL QUANTITY CHECK COPILOT COMPLETES FUEL QUANTITY CHECK 16. FUEL PANEL COPILOT SETS PANEL FOR AIR REFUELING 17. NO SMOKING AND SEAT BELT LIGHTS COPILOT TURNS ON NO SMOKING/ FASTEN SEAT BELT LIGHTS 18. TACAN COPILOT SETS TACAN TO CLOSEST A1G TACAN STATION

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0820 CONTINUES CHECKLIST	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION PILOT- "ROGER"	CP-"PREP FOR CONTACT CHECKLIST COMPLETE"
0821 CONTINUES FLIGHT	FLIES AIRCRAFT/MAINTAINS POSITION AND FUEL AWARENESS	MONITORS POSITION - SCANS OUTSIDE
0822 CONTINUES FLIGHT	FLIES AIRCRAFT/MAINTAINS POSITION AND FUEL AWARENESS	MONITORS POSITION - SCANS OUTSIDE
0823 CONTINUES FLIGHT	FLIES AIRCRAFT/MAINTAINS POSITION AND FUEL AWARENESS	MONITORS POSITION - SCANS OUTSIDE
0824 CONTINUES FLIGHT	FLIES AIRCRAFT/MAINTAINS POSITION AND FUEL AWARENESS	MONITORS FUEL - SCANS OUTSIDE
0825 COMPLETES CHECKLIST	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION BO-"PREP FOR CONTACT CHECKLIST COMPLETE" PILOT-"ROGER BOOM." SELECT MAP DISPLAY ON HSD MONITORS MAP DISPLAY FOR DISTANCE TO ANCHOR	SELECTS HOLD/RDR ON HSD CHECKS GROUND RADAR FOR CHECKPOINT IDENTIFIES CHECKPOINT UPDATES INS COMMUNICATES WITH GCI GCI- "FILIP 66, BLACKBALL, I HAVE A FLIGHT OF CHICKS INBOUND TO ANCHOR" CP-"ROGER BLACKBALL"

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0826 ENTERS ANCHOR AREA	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION TURNS AIRCRAFT TO 215 MONITORS HSD COMMUNICATES WITH TACO33 P - "33, 66 25 MILES TO ARCP, BEGIN TURN TO 215 FOR OUTBOUND LEG" 33 - "33 COPIES 25 MILES TO ARCP TURNING 215 FOR OUTBOUND LEG"	MONITORS POSITION ON HSD MAP DISPLAY COMMUNICATES WITH GCI GCI - "FILIP 66, BLACKBALL, SAY YOUR POSITION." CP - "BLACKBALL, POSITION IS ANCHOR 316 RADIAL AT 25 MILES" GCI - "ROGER 66, SQUAWK IDENT." GCI - "66, BLACKBALL RADAR CONTACT, STANDBY" COMMUNICATES WITH GCI GCI - "FILIP 66, BLACKBALL, I HAVE A FLIGHT OF CHICKS AT 120 MILES SOUTHEAST." CP - "ROGER BLACKBALL."

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0827 FLIES ANCHOR TRACK	FLIES AIRCRAFT	MONITORS POSITION - SCANS OUTSIDE
0828 FLIES ANCHOR TRACK	- SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS POSITION - SCANS OUTSIDE
0829 FLIES ANCHOR TRACK		MONITORS FUEL - SCANS OUTSIDE
0830 FLIES ANCHOR TRACK	FLIES AIRCRAFT	SELECTS WEATHER RADAR ON HSD
	- SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	SCANS WEATHER RADAR SELECTS GROUND MAPPING ON HSD IDENTIFIES LAND MASS
	MONITORS COMMUNICATIONS	CHECKS JN CHART
		DETERMINES POSITION REFERENCE

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0831 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION OBTAINS ETA FROM INS	
		COMMUNICATES WITH PILOT CP - "I'D LIKE THE CREW CHIEF IN THE JUMPSEAT TO BE AVAILABLE TO FURNISH NAVIGATION INFORMATION FROM THE BACKUP CONTROL HEADS. HE COULD ALSO MONITOR THE FUEL PANEL AND ENGINE INSTRUMENTS."
	COMMUNICATES WITH COPILOT P - "THAT'S OK BY ME."	
		COMMUNICATES WITH CREW CHIEF CP - "COPILOT TO CREW CHIEF, PLEASE COME TO THE COCKPIT." CP - "I'D LIKE YOU TO OCCUPY THE JUMPSEAT FOR BACKUP NAVIGATION ASSISTANCE IF REQUIRED. ALSO, I'D LIKE YOU TO HELP MONITOR THE FUEL PANEL AND ENGINE INSTRUMENTS." CREW CHIEF - "ROGER"

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0832 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH COPILOT PILOT - "ROGER"	MONITORS FLIGHT INSTRUMENTS CHECKS TIME COMMUNICATES WITH PILOT CP - "THE TIME IS 0832" IDENTIFIES POSITION - RADAR TURNS ON A/A TACAN SELECTS CHANNEL CONFIRMS POSITION - RADAR PERFORMS CHECKLIST
0833 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH TACO33 PILOT - "TACO33, FILIP 66, WE ARE AT THE DOWNWIND END OF THE ANCHOR TRACK AND INTEND TO TURN LEFT TO COURSE 035" TACO33 - "ROGER, FILIP 66" TURNS TO 035 DEGREES	COMMUNICATES WITH GCI GCI -"FILIP 66, BLACKBALL, STANDBY FOR VIXON, FLIGHT OF 6 A-7s, PRESENTLY 70 MILES FROM ANCHOR" CP - "66, STANDING BY" GCI - "FILIP FLIGHT, FILIP FLIGHT, THIS IS BLACKBALL CONTROL" CP - "BLACKBALL, 66, GO AHEAD" GCI - "ROGER, FILIP 66, BLACKBALL CONTROL. MAKE A LEFT 180 FOR INBOUND TO ANCHOR." CP - "66, ROGER"

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0834 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION MONITORS AIRCRAFT TURN CHECKS WEATHER CHECKS ACRT	COMMUNICATES WITH GCI VIX - "BLACKBALL, VIXON. I HAVE TALLY HO ON THE TANKER." GCI - "ROGER, VIXON, BLACKBALL, CLEAR MY FREQUENCY." GCI - "VIXON FLIGHT, GO REFUELING COMMON. (326.6)." VIX - "VIXON LEAD, 2, 3, 4, 5, 6."
0835 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION ROLLS OUT ON TRACK COMMUNICATES WITH RECEIVERS/COMM1 VIX - "FILIP 66, THIS IS VIXON LEADER. WE ARE A FLIGHT OF 6 A-7s IN NEED OF REFUELING." P - "ROGER, VIXON LEADER"	

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0836 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION MONITORS WEATHER COMMUNICATES WITH VIXON AND TACO 33 P - "VIXON, 66, LINE UP IS 3 VIXONS ON EACH TANKER. WHAT ARE YOUR FUEL REQUIREMENTS AND ARMAMENT STATUS?" VIX - "ROGER 66, YOU WANT 3 VIXONS ON TANKER 1 AND 3 VIXONS ON TANKER 2. BE ADVISED WE NEED ABOUT 4 THOUSAND EACH FOR TOP OFF. ARMAMENT IS SAFE." P - "66, 4 THOUSAND POUNDS, COPY." TACO 33 - "33, COPY LINEUP."	
0837 FLIES ANCHOR TRACK 0838 FLIES ANCHOR TRACK 0839 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS POSITION - SCANS OUTSIDE MONITORS POSITION - SCANS OUTSIDE MONITORS FUEL - SCANS OUTSIDE

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0840 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION MONITORS ANCHOR DISPLAY MONITORS WEATHER	COMMUNICATES WITH GCI GCI - "FILIP 66, BLACKBALL, VIXON FLIGHT SHOULD BE APPROACHING SHORTLY." CP - "ROGER BLACKBALL."
0841 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS PILOT - SCANS OUTSIDE
0842 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION LOOKS FOR RECEIVERS	COMMUNICATES WITH GCI GCI - "FILIP FLIGHT, THIS IS BLACKBALL CONTROL." CP - "BLACKBALL, 66, GO AHEAD." GCI - "ROGER FILIP. BE ADVISED I AM STARTING TO PAINT SIGNIFICANT WEATHER ON YOUR ANCHOR TRACK. DO YOU PAINT?" CP - "ROGER BLACKBALL, WE PAINT THE WEATHER TOO." GCI - "ROGER 66, YOU'RE CLEARED TO DEVIATE FOR WEATHER. KEEP ME ADVISED."

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0843 FLIES ANCHOR TRACK	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	OPERATES FUEL PANEL FORWARD BODY ON AFT BODY OFF
0844 AIR REFUELING CONTROL TIME	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION SPOTS VIXON COMMUNICATES WITH TACO33 TACO33 - "66, 33, WE HAVE TALLY HO ON VIXON FLIGHT." PILOT - "ROGER 33." TURNS AIRCRAFT	COMMUNICATES WITH GCI GCI - "FILIP 66, BLACKBALL, IDENT. (PAUSE) OPERATES IFF GCI - "ROGER 66, SAY YOUR POSITION FROM ANCHOR FIX." CP - "BLACKBALL, 66, WE ARE APPROACHING ANCHOR POINT." GCI - "ROGER 66, BLACKBALL, I HAVE YOU NOW." CP - "ROGER BLACKBALL." GCI - "66, BLACKBALL, TURN LEFT TO INTERCEPT DOWNWIND TRACK." CP - "ROGER BLACKBALL." GCI - "66, BLACKBALL, TRANSFERING VIXON FLIGHT TO YOUR CONTROL." CP - "ROGER BLACKBALL."

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0845 IN ANCHOR AREA	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS PILOT - SCANS OUTSIDE
0846 IN ANCHOR AREA	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION ROLLS OUT ON TRACK ESTABLISHES NEW HEADING COMMUNICATES WITH GCI, TACO33, VIXON P - "BLACKBALL, 66, OUR NEW HEADING IS 215 DEGREES." GCI - "BLACKBALL COPIES." TACO33 - "33 COPIES." VIXON - "VIXON COPIES." COMMUNICATES WITH BOOMER BOOM - "TALLY HO ON VIXON." PILOT - "BOOMER CLEARED TO COMM #1" BOOM - "ROGER."	
0847 IN ANCHOR AREA	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION MONITORS ANCHOR DISPLAY MONITORS WEATHER DISPLAY COMMUNICATES WITH TACO33 PILOT - "TACO33, AIRSPEED IS 305 IAS." TACO33 - "ROGER, 305 IAS."	CHECKS FUEL PANEL FOR REFUELING FROM FORWARD BODY COMMUNICATES WITH CREW CP - "PREP FOR CONTACT CHECKLIST COMPLETE" MONITORS COMMUNICATION WITH VIXON BOOM - "VIXON LEADER CLEAR TO PRECONTACT, VIXON 2 & 3 CLEARED TO LEFT WING VIXON - "VIXON PRECONTACT, ROGER."

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0848 IN ANCHOR AREA	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS PILOT - SCANS OUTSIDE
0849 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION MONITOR AIRSPEED (305 IAS) MONITOR WEATHER	MONITORS COMMUNICATIONS WITH VIXON LEAD BO - "BOOM 66, CONTACT." VIX - "VIXON LEAD, CONTACT." SWITCH ON REFUELING VALVE MONITORS FUEL OFFLOAD MONITORS LOCATION MONITORS WEATHER
0850 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS PILOT - SCANS OUTSIDE
0851 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	SWITCH OFF REFUELING VALVE MONITORS COMMUNICATION WITH VIXON LEAD BO - "VIXON LEAD, DISCONNECT NOW." VIX - "VIXON LEAD, DISCONNECT." BO - "VIXON LEAD, CLEAR OF BOOM 3800 POUNDS." VIX - "VIXON LEAD COPIES 3800." RECORDS FUEL OFFLOADED

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0852 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS COMMUNICATIONS WITH VIXON 2 BO - "VIXON 2, CLEAR TO CONTACT." VIX - "VIXON 2 COPIES."
0853 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS COMMUNICATIONS WITH VIXON 2 BO - "BOOM 66, CONTACT." VIX - "VIXON 2, CONTACT." SWITCH ON REFUELING VALVE MONITORS FUEL OFFLOAD
0854 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION STARTS TURN FROM DOWNWIND LEG COMMUNICATES WITH TACO33 PILOT - "TACO33, FILIP 66, WE'RE BEGINNING OUR TURN TO INBOUND LEG NOW." TACO33 - "33 COPIES TURN."	COMMUNICATES WITH GCI GCI - "FILIP 66, BLACKBALL, TURN INBOUND TO ANCHOR. I HAVE MORE CUSTOMERS IN LINE, A VENOM FLIGHT OF 4 F-16s. TWO OF WHICH HAVE MINIMUM FUEL. THEY ARE 50 MILES FROM YOUR TRACK." CP - "66, COPY."
0855 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	SWITCHES OFF REFUELING VALVE MONITORS COMMUNICATION WITH VIXON 2 BO - "VIXON 2, DISCONNECT NOW." VIX - "VIXON 2, DISCONNECT."

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0856	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION ROLLS OUT ON TRACK COMMUNICATES WITH GCI GCI - "FILIP FLIGHT, THIS IS BLACKBALL CONTROL." P - "66, GO AHEAD BLACKBALL." GCI - "ROGER, SIR, YOUR CHICKS ARE AT 30 MILES INBOUND. CALL SIGN IS VENOM." P - "ROGER BLACKBALL." COMMUNICATES WITH BOOMER PILOT - "BOOM, PILOT, HOW ARE WE COMING WITH THE VIXON FLIGHT?" BOOM - "BOOM, TWO DOWN, ONE TO GO!" SCANS FOR VENOM FLIGHT	MONITORS COMMUNICATION WITH VIXON 2 BO - "VIXON 3, CLEAR OF BOOM 4200 POUNDS." VIX - "VIXON 2 COPIES 4200." RECORDS FUEL OFFLOADED COMMUNICATES WITH VENOM CP - "VENOM FLIGHT, THIS IS FILIP 66, CHECK IN PLEASE." VENOM - "66, THIS IS VENOM FLIGHT. WE ARE A FLIGHT OF 4 F-16s AND DESIRE ABOUT 8000 POUNDS PER BIRD. WE HAVE TWO BIRDS AT MINIMUM FUEL. WE ANTICIPATE REFUELING AT FL 290 AND OUR ARMAMENT IS SAFE." CP - "ROGER VENOM FLIGHT."
0857 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS COMMUNICATION WITH VIXON 3 BO - "BOOM 66, CONTACT." VIX - "VIXON 3, CONTAC T." SWITCHES ON REFUELING VALVE MONITORS FUEL OFFLOAD

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0858 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	SWITCHES ON CENTER WING TANK DRAINS CENTER WING FUEL FORWARD
	COMMUNICATES WITH CREW PILOT - "TALLY HO, VENOM FLIGHT 2 O'CLOCK AT 12 MILES."	COMMUNICATES WITH GCI CP - "BLACKBALL, FILIP 66, WE HAVE SIGHTING ON VENOM FLIGHT. WE HAVE NOT COMPLETED REFUELING VIXON FLIGHT BUT WE WILL ACCEPT HANDOFF OF VENOM FLIGHT."
	COMMUNICATES WITH VIXON PILOT - "VIXON FLIGHT WE HAVE TALLY HO ON VENOM FLIGHT INBOUND." VIXON - "ROGER."	BLACKBALL - "ROGER 66." SWITCHES OFF REFUELING VALVE MONITORS COMMUNICATION WITH VIXON 3 BO - "VIXON 3, DISCONNECT NOW."
	COMMUNICATES WITH TACO33 TACO33 - "TACO33 HAS TALLY HO ON VENOM FLIGHT." PILOT - "ROGER 33."	VIX - "VIXON 3, DISCONNECT." BO - "VIXON 3, CLEAR OF BOOM 4500 POUNDS." VIX - "VIXON 3 COPIES 4500 POUNDS." RECORDS FUEL OFFLOADED

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0859 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH VIXON FLIGHT PILOT - "VIXON, 66, YOU'RE CLEAR TO DEPART AREA." VIXON - "ROGER 66, THANKS FOR THE GAS." COMMUNICATES WITH BOOMER PILOT - "BOOM, CLEAR TO CONTACT VENOM FLIGHT." BOOM - "BOOM, ROGER." COMMUNICATES WITH TACO33 PILOT - "33, 66, PUSH IT UP TO 315 IAS." TACO33 - "33, 315 INDICATED, ROGER." COMMUNICATES WITH BOOMER AND TACO33 P - "LINE UP IS TWO BIRDS PER TANK, VENOM 1 & 2 ON 66, VENOM 3 & 4 ON 33." TACO33 - "33, ROGER 66." BOOMER - "BOOM, ROGER."	MONITORS COMMUNICATION WITH VENOM 1 BO - "VENOM 1, BOOM 66, HOW COPY?" VEN - "66, VENOM 1 READS YOU 5." BO - "VENOM 1, CLEAR TO PRECONTACT." VEN - "VENOM 1 COPIES."
0900 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS POSITION - SCANS OUTSIDE

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0901 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION MONITORS ANCHOR DISPLAY MONITORS WEATHER	MONITORS COMMUNICATION WITH VENOM 1 BO - "BOOM 66, CONTACT." VEN - "VENOM 1, CONTACT." SWITCHES ON REFUELING VALVE COMMUNICATES WITH GCI CP - "BLACKBALL, 66, VENOM LEADER TELLS US THAT VENOM 5 IS INBOUND WITH A LOW FUEL SITUATION." GCI - "ROGER 66, YOU'RE CLEAR TO CONTACT VENOM 5." COMMUNICATES WITH VENOM 5 CP -"VENOM 5, FILIP 66, WHAT IS YOUR STATUS?" VEN - "VENOM 5, 66, I AM DOWN TO EMERGENCY FUEL AND THROTTLED BACK, I DON'T THINK I HAVE ENOUGH FUEL TO MAKE IT BACK TO YOUR LOCATION." CP - "VENOM 5, 66, STANDBY."
0902 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH COPILOT PILOT - "VECTORS OK, SET UP COURSE TO MEET VENOM 5 AS SOON AS WE CLEAR VENOM 1." STARTS TURN SOUTH COMMUNICATES WITH TACO33 PILOT -"33, 66, WE WILL GO MEET VENOM 5. YOU STAY IN TRACK WITH THE REST OF VENOM FLIGHT AND WE'LL REJOIN YOU LATER." TACO33 -"ROGER 66, GOOD LUCK."	COMMUNICATES WITH GCI CP - "BLACKBALL, 66, CAN YOU GIVE ME A VECTOR FOR VENOM 5?" GCI - "ROGER 66, VENOM 5 IS 100 MILES SOUTH OF YOU ON COURSE 180. PROCEED THERE RAPIDLY, AS HIS FUEL SITUATION IS CRITICAL." CP - "ROGER BLACKBALL." INPUTS RENDEZVOUS DATA IN NAV MANAGEMENT SYSTEM

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0903 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSITE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS PILOT - SCANS OUTSIDE
0904 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION SELECTS RENDEZVOUS ON HSD DISPLAY COMMUNICATES WITH TACO33 PILOT - "33, 66." TACO33 - "33 COPIES." PILOT - "66 TERMINATING CELL TO RENDEZVOUS WITH VENOM 5. SUGGEST YOU REFUEL REMAINING VENOM CHICKS AND WAIT OUR RETURN." TACO33 - "ROGER 66." ADVANCES POWER TO MAX COMMUNICATES WITH COPILOT PILOT - "SEE IF YOU CAN RAISE VENOM 5." COPILOT - "ROGER." COMMUNICATES WITH GCI GCI - "66, VENOM 5 THROTTLED BACK FOR MAXIMUM ENDURANCE." PILOT - "ROGER BLACKBALL."	SWITCHES OFF REFUELING VALVE MONITORS COMMUNICATION WITH VENOM 1 BO - "VENOM 1, DISCONNECT NOW." VEN - "VENOM 1, DISCONNECT." BO - "VENOM 1, CLEAR OF BOOM 9300 POUNDS." VEN - "VENOM 1 COPIES 9300 POUNDS." RECORDS FUEL OFFLOADED COMMUNICATES WITH GCI CP - "BLACKBALL, FILIP 66." GCI - "GO AHEAD 66." CP - "FILIP 66 TERMINATING CELL TO RENDEZVOUS WITH VENOM 5. WE WILL LEAVE TACO33 IN TRACK TO COMPLETE REFUELING OF VENOM FLEET. TACO33 HAS NAV SYSTEM MALFUNCTION. WE WILL RETURN TO TRACK AFTER RENDEZVOUS WITH VENOM "5". GCI - "COPY 66."

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0905 AERIAL REFUELING	FLIES AIRCRAFT	MONITORS POSITION - SCANS OUTSIDE
0906 AERIAL REFUELING	- SCAN OUTSIDE AIRCRAFT	MONITORS POSITION - SCANS OUTSIDE
0907 AERIAL REFUELING	- SCAN INSIDE AIRCRAFT - ANALYZE RESULTS	MONITORS POSITION - SCANS OUTSIDE
0908 AERIAL REFUELING	- APPLY CONTROL ACTION	MONITORS FUEL - SCANS OUTSIDE
0909 AERIAL REFUELING		MONITORS POSITION - SCANS OUTSIDE
0910 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION MONITORS POSITION MONITORS WEATHER TURNS 180 TO NORTH	COMMUNICATES WITH GCI GCI -"FILIP 66, THIS IS BLACKBALL CONTROL, START A 180° TURN TO THE RIGHT AT THIS TIME. VENOM 5 IS 12 O'CLOCK 20 MILES. BE ADVISED YOU ARE PRESSING THE BORDER." CP - "FILIP 66." COMMUNICATES WITH VENOM 5 CP - "VENOM 5, FILIP 66, CHECK IN." VEN - "ROGER 66, VENOM 5. MY FLIGHT LEVEL IS 290, ARMAMENT SAFE, FUEL IS EXTREMELY LOW, AND I'D LIKE ABOUT 9000 POUNDS." CP - "COPY VENOM 5."

AD-A111 948 NORTHROP CORP HAWTHORNE CA AIRCRAFT DIV F/G 1/3
CREW WORKLOAD PREDICTION STUDY.(U)
DEC 81 J F WATLER, D W ROWELL, S S JANOSKI F33615-80-C-3618
UNCLASSIFIED AFWAL-TR-81-3140 NL

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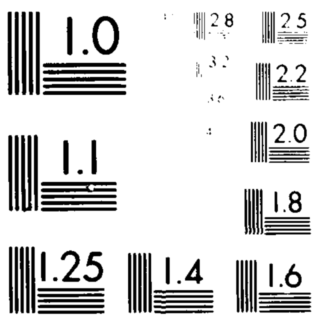

MICROCOPY RESOLUTION TEST CHART

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0911 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION CONTINUES TURN COMMUNICATES WITH BOOMER PILOT - "BOOM, PILOT, PREPARE FOR IMMEDIATE HOOKUP WITH VENOM 5. YOU'RE CLEARED TO COMM 1." BOOMER - "BOOM,ROGER."	COMMUNICATES WITH CREW CP - "TALLY HO ON VENOM 5." CHECKS FUEL PANEL
0912 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION ROLLS OUT OF TURN SETS COURSE MONITORS WEATHER ADJUSTS SPEED (315 IAS)	CHECKS POSITION CHECKS WEATHER COMMUNICATES WITH TACO33 CP - "33, 66, REQUEST BEACON FOR RENDEZVOUS IN ANCHOR PATTERN." 33 - "33,ROGER, WE'RE STILL IN THE TRACK AND FINISHING UP REFUELING OF OTHER VENOM CHICKS."
0913 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH COPILOT PILOT - "OK TO ACCEPT ORBIT AFTER VENOM 5 IS STABLE TAKING FUEL."	COMMUNICATES WITH GCI GCI - "FILIP FLIGHT, THIS IS BLACKBALL CONTROL." CP - "66, GO AHEAD BLACKBALL." GCI - "ROGER FILIP, I HAVE A SINGLE SHIP INBOUND TO YOU AT THIS TIME. CALL SIGN VAMPIRE 3. HE'S AN RF-4." CP - "66 COPIES." GCI - "ROGER 66, BLACKBALL, SINGLE CHICK IS ABOUT 80 MILES OUT." CP - "66,ROGER."

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0914 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH COPILOT PILOT - "DIRECT VIXON 7 TO TACO33."	COMMUNICATES WITH TACO33 AND GCI CP - "TACO33, 66, WE WILL ACCEPT ORBIT FOR VAMPIRES." 33 - "33 COPIES." GCI - "BLACKBALL COPIES, YOU HAVE ANOTHER SINGLE CHICK INBOUND, VIXON 7 WILL YOU ACCEPT ORBIT?" CP - "STANDBY." CP - "BLACKBALL, DIRECT VIXON 7 TO TACO33." GCI - "ROGER 66." 33 - "33 COPIES." MONITORS COMMUNICATION WITH VENOM 5 BO - "66, CONTACT." VEN - "VENOM 5, CONTACT."
0915 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION STARTS LEFT ORBIT WITH VENOM 5 VERIFIES POSITION	SWITCHES ON REFUELING VALVE MONITORS FUEL OFFLOAD COMMUNICATES WITH VAMPIRE 3 CP - "VAMPIRE 3, 66, CHECK IN." VAM - "ROGER 66, VAMPIRE 3, LOW ON FUEL FLIGHT LEVEL 290, ARMAMENT SAFE, DESIRING 10,000 POUNDS OF FUEL. ALSO, DISABLED DUE TO AERIAL ENCOUNTER AND LOSING FUEL." CP - "COPY VAMPIRE 3."
0916 AERIAL REFUELING 0917 AERIAL REFUELING 0918 AERIAL REFUELING 0919 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	SWITCHES ON TANKS 1, 2, 3, 4, AND AFT BODY SWITCHES OFF CENTER WING TANK MONITORS POSITION - SCANS OUTSIDE

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0920 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION ROLLS OUT OF ORBIT HEADING NORTH VERIFIES POSITION 25 MILES SE GOTLAND ISLAND COMMUNICATES WITH CREW PILOT - "TALLY HO ON VAMPIRE 3."	SWITCHES OFF REFUELING VALVE RECORDS FUEL OFFLOADED MONITORS COMMUNICATION WITH VENOM 5 BO - "VENOM 5, DISCONNECT NOW." VEN - "VENOM 5, DISCONNECT." BO - VENOM 5, CLEAR OF BOOM WITH 10,000 POUNDS." VEN - "VENOM 5 COPIES, 10,000 POUNDS." COMMUNICATES WITH GCI GCI - "FILIP 66, THIS IS BLACKBALL CONTROL." CP - "66, GO AHEAD BLACKBALL." GCI - "ROGER, SIR, WE HAVE UNIDENTIFIED AIRCRAFT ON OUR SCOPE AT THIS TIME, APPROXIMATELY 190 MILES EAST OF YOUR POSITION." CP - "ROGER. I UNDERSTAND BANDITS 190 MILES IN THE EAST."
0921 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS PILOT - SCANS OUTSIDE

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0922 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH GCI GCI - "FILIP 66, THIS IS BLACKBALL CONTROL." PILOT - "66, GO AHEAD BLACKBALL." GCI - "ROGER, SIR. WE HAVE BANDITS 50 MILES FROM THE EAST." PILOT - "66 COPIES, CAN WE GET SOME FIGHTER ASSISTANCE." GCI - "ROGER 66."	MONITORS COMMUNICATION WITH VAMPIRE 3. BO - "BOOM 66, CONTACT." VAM - "VAMPIRE 3, CONTACT." SWITCHES ON REFUELING VALVE MONITORS FUEL OFFLOAD COMMUNICATES WITH GCI GCI - "ALPHA, ALPHA, LIMA, BRAVO, OSCAR, ROMEO, GOLF (PAUSE), ROMEO, ECHO, CHARLIE, OSCAR, VICTOR, ECHO, ROMEO, YANKEE (PAUSE), CHARLIE, OSCAR, NOVEMBER, FOXTROT, INDIA, ROMEO, MIKE, ECHO, DELTA." DECODES MESSAGE COMMUNICATES WITH CREW CP - "WE'VE BEEN CONFIRMED FOR AALBORG RECOVERY."
0923 AERIAL REFUELING	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	SWITCHES ON #1 R & #4 R TANK VALVES

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0924 ELECTROMAGNETIC PULSE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH GCI GCI - "FILIP 66, BLACKBALL,WE HAVE FRIENDLIES INBOUND TO ASSIST WITH BOGIES." PILOT - "ROGER BLACKBALL." COMMUNICATES WITH TACO33 PILOT - "TACO33, FILIP 66, RECOVERY AT AALBORG CONFIRMED." TACO33 - "ROGER 66, GOOD LUCK." DETECTS EXPLOSION SCANS INSIDE AIRCRAFT FOR EQUIPMENT OPERABILITY NOTES EQUIPMENT LOSS - AVIONICS - AUTOPILOT DISCONNECT ATTEMPTS COMMUNICATION WITH TACO33 PILOT - "TACO33, FILIP 66, DO YOU COPY?" NO RESPONSE	SWITCHES OFF REFUELING VALVE RECORD FUEL OFFLOAD MONITORS COMMUNICATION WITH VAMPIRE 3 BO - VAMPIRE 3, DISCONNECT NOW." VAM - "VAMPIRE DISCONNECT." BO - "CLEAR OF BOOM WITH 10,000 POUNDS VAM - "VAMPIRE 3 COPIES 10,000 POUNDS COMMUNICATES WITH CREW CP - "TALLY HO ON BOGIES AT 15 MILES." CP - "BOOMER STOW THE BOOM AND COME FORWARD." BOOM - "BOOM, COPY." DETECTS EXPLOSION NOTES EQUIPMENT LOSS - AVIONICS ATTEMPTS COMMUNICATION WITH BOOMER CP - "BOOMER DO YOU COPY?" NO RESPONSE
0925 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION TURNS LEFT TOWARD WEST DESCENDS	SCANS OUTSIDE FOR BOGIES

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0926 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION CONTINUES TURN/DESCENT COMMUNICATES WITH COPILOT PILOT - "FIND OUT HOW MUCH EQUIPMENT DAMAGE WE SUSTAINED." COPILOT - "ROGER." PILOT - "CREW CHIEF, CHECK CABIN, WINGS AND ENGINE FOR PHYSICAL DAMAGE." CREW CHIEF - "ROGER." CHECKS INTERCOM CHECKS COMM RADIO CHECKS BATTERY BACKUP	MONITORS PILOT - SCANS OUTSIDE ASSESSES DAMAGE CHECKS COMM SYSTEM CHECKS NAV SYSTEM CHECKS FLIGHT DIRECTOR CHECKS AUTOPILOT DISCOVERS BOOM OFFICER FLASH BLINDED
0927 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION LEVELS AIRCRAFT AT FL140 LEVELS WINGS STABILIZES AIRSPEED CHECKS COMPASS WITH STANDBY FLIES HEADING 255 COMMUNICATES WITH CREW CREW CHIEF - "NO VISIBLE DAMAGE TO AIRCRAFT, BUT BOOM IS NOT STOWED." PILOT - "ROGER."	COMMUNICATES WITH PILOT COPILOT - "THE FOLLOWING SYSTEMS ARE INOP OR UNRELIABLE: COMM SYSTEMS INOP VOR INOP TACAN INOP INS UNRELIABLE DOPPLER UNRELIABLE FLIGHT DIRECTOR INOP WILL YOU CHECK THE AUTOPILOT." PILOT - "ROGER."

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0928 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION CHECKS AUTOPILOT, INOP DISCONNECTS AUTOPILOT COMMUNICATES WITH CREW CHIEF PILOT - "WILL YOU GO BACK AND TRY TO STOW THAT BOOM." CREW CHIEF - "ROGER." COMMUNICATES WITH COPILOT PILOT - "THE AUTOPILOT IS OUT, WE'LL HAVE TO FLY MANUALLY FOR THE REST OF THE FLIGHT." COPILOT - "ROGER."	REMOVES RADIATION CURTAINS OBSERVES WEATHER COMMUNICATES WITH PILOT CP -"HERE IS A FURTHER STATUS REPORT RADAR INOP ALL MODES AIRSPEED OK ALTIMETERS OK INCLINOMETERS OK ELECTROMECH INSTRUMENTS INOP ENGINE INSTRUMENTS OK ELECTRICAL INDICATORS INOP." PILOT - "ROGER."
0929 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION HEADING WSW FL140 COMMUNICATES WITH CREW CHIEF CREW CHIEF - "THE BOOM IS STILL IN TRAIL AND WILL NOT STOW." PILOT - "ROGER, WILL YOU ASSIST US FROM THE JUMPSEAT TO MONITOR REMAINING ENGINE AND SYSTEMS INSTRUMENTS AND TO WATCH FOR OTHER AIRCRAFT." CREW CHIEF - "ROGER."	MONITORS FLIGHT INSTRUMENTS MONITORS ENGINE INSTRUMENTS MONITORS SUBSYSTEMS WATCHES FOR OTHER AIRCRAFT NOTES UNDERCAST

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0930 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS PILOT - SCANS OUTSIDE
0931 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH CREW PILOT - "AIRCRAFT IS FLYABLE, THOUGH FLIGHT WILL BE THROUGH MANUAL MEANS. WE HAVE A GOOD CHANCE TO RECOVER, BUT WE MUST GET OUR BEARINGS AND LAND-MARKS."	COMPLETES DAMAGE ASSESSMENT COMMUNICATES WITH PILOT CP - "THE AIRCRAFT IS BASICALLY FLYABLE WITH MINIMUM FLIGHT INSTRUMENTATION AND NO NAV AIDS OR RADAR." PILOT - "ROGER." COMPUTES POSITION
0932 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS PILOT - SCANS OUTSIDE

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0933 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH CREW PILOT - "THE PLAN IS ESSENTIALLY THIS: FLY WSW MAINTAINING POSITION BY TIME AND DISTANCE CALCULATIONS."	MONITORS PILOT - SCANS OUTSIDE
0934 ANCHOR DEPARTURE 0935 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	MONITORS POSITION - SCANS OUTSIDE COMPUTES TIME AND DISTANCE COMPUTES FUEL REQUIRED VS FUEL REMAINING
0936 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH COPILOT PILOT - "WILL YOU DETERMINE: ETE DENMARK ETA DENMARK FUEL REMAINING." CP - "ROGER."	COMPUTES POSITION COMMUNICATES WITH PILOT CP - "PRESENT POSITION IS ABEAM OF BODA SWEDEN, 300 MILES WEST OF DENMARK, ETE IS 45 MINUTES, ETA IS 1021, FUEL REMAINING 30,000 POUNDS USEABLE."

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0937 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION COMMUNICATES WITH CREW CHIEF AND COPILOT PILOT - "GO BACK AND USE AN EMERGENCY HOIST TO STOW THAT BOOM."	REVIEWS EMERGENCY BOOM HOIST PROCEDURES WITH CREW CHIEF COMMUNICATES WITH CREW CHIEF CP - "GO TO BOOM POD TO COMPLETE THE POST REFUELING CHECKLIST. I'LL JOIN YOU SHORTLY." CREW CHIEF - "ROGER." DEPARTS TO CARGO COMPT
0938 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION MAINTAINS FL140 (VMC) MAINTAINS CRUISE AIRSPEED	COMPLETES BOOM CHECKLIST OBSERVES PUMPS INOP OPERATES MANUAL VALVES OPERATES HAND PUMP RETURNS TO COCKPIT COMMUNICATES WITH PILOT CP - "WE NEED TO FLY SLOWER TO RETRACT THE BOOM." PILOT - "ROGER, WILL DO." RETURNS TO CABIN
0939 ANCHOR DEPARTURE	FLIES AIRCRAFT - SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	

TIME/BLOCK NAME	PILOT TASKS	COPILOT TASKS
0940 BOOM STOWAGE	FLIES AIRCRAFT	OPERATES HOIST PUMP
	SLOWS TO 200 KIAS	TURNS BOOM BYPASS VALVE
	- SCAN OUTSIDE AIRCRAFT - SCAN INSIDE AIRCRAFT - ANALYZE RESULTS - APPLY CONTROL ACTION	WAVES CREW CHIEF FORWARD RETURNS TO COCKPIT COMMUNICATES WITH PILOT CP - "THE BOOM IS STOWED." PILOT - "ROGER."

BASAL TANKER AIRCRAFT COMMANDER TASKS

Mission Mode; on anchor track or base leg of pattern 60 second sequence.

- o Scan out of Cockpit and Determine:

    Aircraft Attitude and Position

    Airspace Safety - Collision Avoidance - Surveillance

    Weather - Cell and frontal activity of local weather threat

- o Scan Cockpit Displays and Determine:

    Status - Indicators as req'd for attitude warning/FD mode, etc.

    Attitude - Pitch, Roll on Attitude Director Indicator

    Speed/Mach - Airspeed Indicator - (Mach meter as req'd)

    Course - Azimuth on Horizontal Situation Display

    Rate of turn/slip-skid - attitude director indicator

    Time in turn - Clock, Horizontal Situation Ind, ADI

    Rate of climb - Vertical Velocity Indicator

    Altitude - Baro Altimeter

    Power/Thrust - Engine Pressure Ratio Indicators, Fuel Flow

    Pitch Trim Limits - Trim wheel

    Weather - Storm activity on Weather Radar

    All subsystems - within limits, no ınnunciators

    Fuel - Fuel remaining distribution for offload preparation and C.G.

    Heading - HSE/HSD, RMI , standby compass for proper headings

    Environment Control - best comfort settings

    Wind - ground speed, drift, TAS

    Flight Director Commands - course error

    Position Awareness - Check lat/long. against ground map radar position

- o Control Action to maintain an established flight profile is based on observed data and predetermined parameters of performance required to maintain the flight profile.
- o Decisions: (Based on observed data)

    Pitch, roll and yaw attitude correct

o <u>Decisions: (Based on observed data) (cont)</u>

Flight director commands satisfied

Pitch reference set

Turn & skid indices correct (turn rate)

Airspeed correct

Altitude correct

Vertical velocity correct

Thrust/power setting correct and symetrical - icing?

Heading correct

Heading/course bugs set

ACFT on track

Pitch trim within limits (center of gravity)

Autopilot engaged and in correct mode when used

Time to start Standard Rate Turn (SRT) to base/to anchor track (time on track)

Local airspace clear. Position of RCVR ACFT and No. 2 Tanker

Weather activity - time to complete mission - direction of storm cell.

Airplane capable of continuing the mission. RDR intensity/range/tilt/mode

Course correct

INS drift note and/or correct

All subsystems operating indications note and/or correct

Fuel distribution correct

*U.S.Government Printing Office: 1982 — 559-005/4045